Content of Lesson 2

Unit 1: Introduction

Unit 2: Individual spatial properties of features

Unit 3: Spatial pattern and neighborhood of features

Unit 4: Weighted spatial pattern and neighborhood

Unit 5: Regionalization

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Unit 4: Weighted spatial pattern and neighborhood

A: Introduction

B: Weighted spatial pattern and neighborhood

- for point features
- for linear features
- for areal features

1 Introduction

Weighted spatial pattern and neighborhood

Our everyday experience suggests that spatial pattern and neighborhood are influenced by thematic properties of features

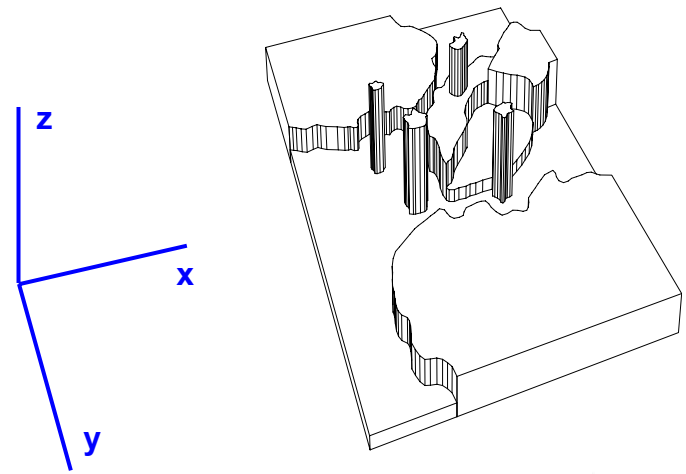
- **It is then necessary to combine their geometrical properties with their thematic properties**
  - This combination is obtained by weighting their geometry as well as the spatial relationships between features
- **It is therefore necessary to choose a spatial model that integrates the two spatial and thematic dimensions:**
  - Isotropic weighted space: a space with heterogeneous properties, weighted distance

Model of space: Isotropic weighted space

- **Properties within the space are heterogeneous, they influence properties of arrangement and neighborhood:**
  - spatial and thematic properties should be considered simultaneously
- **The description of features pattern and neighborhood combines geometric and thematic properties by weighting:**
  - weighted central tendancy and dispersion
  - weighted proximity: weighted distance

- **Space is modelised as weighted, expressing heterogeneous properties in space**
- **Properties are considered as isotropic:**

  they are constant with respect to direction



Weighting of geometric properties

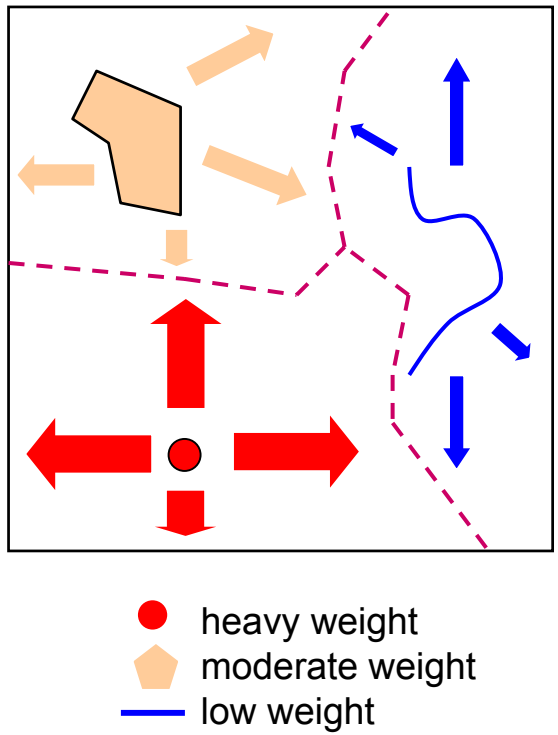
Neighborhood relationships are describes by indices that combine geometric and thematic properties using weighting

- **Thematic properties assigned to space locations or features may express:**
  - **the weight of features**, expressing their importance, their influence or their attractiviness. Such properties allow the definition of a field of influence for each feature (area of largest weighted proximity)
  - **the friction of locations** in space, expressing the difficulty of access, of movement or the proximity to features (weighted distance)

Weighting: Weight of features

Geometrical properties are weighted by the relative importance of features

- **It is a modification of the metrics:**
  - **w_i = weight of feature i**
- **This weighting allows to define a potential field of influence for each of the features:**
  - space is divided into areas of largest weighted proximity

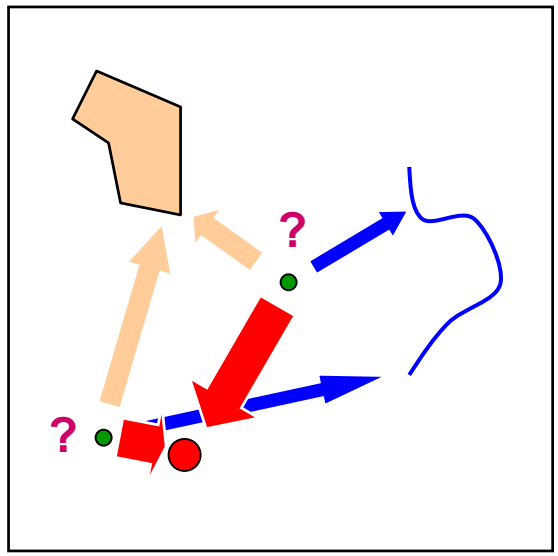


Weighting: Proximity to features

Geometrical properties are weighted by the relative friction of accessibility to features

- **It is a modification of the metrics:**
  - ω_i = 1 / weight of feature i
  - so: $dp_i = d_i * \omega_i$
- **This coefficient of friction allows to define:**
  - an area of weighted distance to each feature
  - the minimum weighted distance from each location in space to features

Further concepts of pathway, barrier (obstacle), force and anisotropy will be considered in Lesson dedicated to accessibility



low friction, high accessibility
moderate friction, moderate accessibility
heavy friction, low accessibility

Description of spatial pattern and neighborhood

Proposed indices of pattern and neighborhood

Indices	Plane space spatial dimension	Weighted space spatio-thematic dimension
Location	Mean, median centers	Weighted mean center
Dispersion	Standard deviations, interquartiles, standard distance, R index	Weighted standard deviation
Proximity	Plane distance, areas of largest proximity	Weighted distance, areas of largest weighted proximity

- **Indices and statistics of weightedspatial pattern and neighborhood are presented according to the type of spatial features:**
  - point
  - linear
  - areal

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Weighted spatial pattern and neighborhood of point features

Point features: Weighted pattern and neighborhood

Different indicators for the spatial distribution and relationships of point features

- **Spatial distribution description:**
  - statistical indices of location: central tendency
  - statistical indices of dispersion: variability
- **Neighborhood relationships description:**
  - weighted distance to features
  - areas of largest weighted proximity

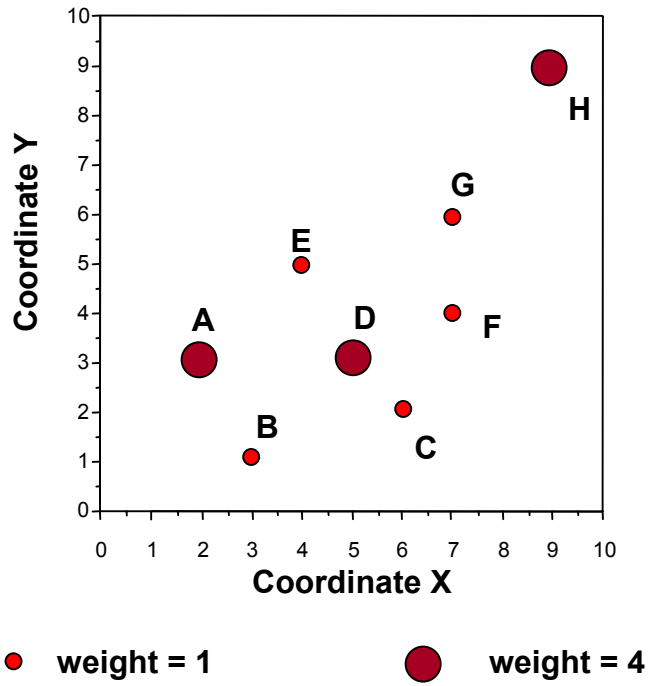
Point features : Example of a distribution

Location and weight of 8 points

Point	X(m)	Y(m)	Z(weight)
A	2.0	3.0	4
B	3.0	1.0	1
C	6.0	2.0	1
D	5.0	3.0	4
E	4.0	5.0	1
F	7.0	4.0	1
G	7.0	6.0	1
H	9.0	9.0	4

Thematic properties of points are heterogeneous. They are considered as relative weights for the computation of spatio-thematic indices

Spatial distribution of the 8 points with their respective weight



Point features : Central tendency index

Based on the weighted mean of X and Y coordinates

- **Mean center MC ($\bar{x}_w$, $\bar{y}_w$) or ($x_{w\ mean}$, $y_{w\ mean}$) :**

$$\bar{x}_w = \sum_{i=1}^{n} x_i w_i \Big/ \sum_{i=1}^{n} w_i \qquad \bar{y}_w = \sum_{i=1}^{n} y_i w_i \Big/ \sum_{i=1}^{n} w_i$$

w_i = thematic value (weight) for point i

  - it is the weighted center of gravity or the weighted barycenter for the point distribution

Point features : Weighted mean center

Point	Coord. X	Coord. Y	Weight w	X * w	Y * w
A	2	3	4	8	12
B	3	1	1	3	1
C	6	2	1	6	2
D	5	3	4	20	12
E	4	5	1	4	5
F	7	4	1	7	4
G	7	6	1	7	6
H	9	9	4	36	36
Σ	43	33	17	91	78
Mean	5.375	4.125		**5.353**	**4.588**

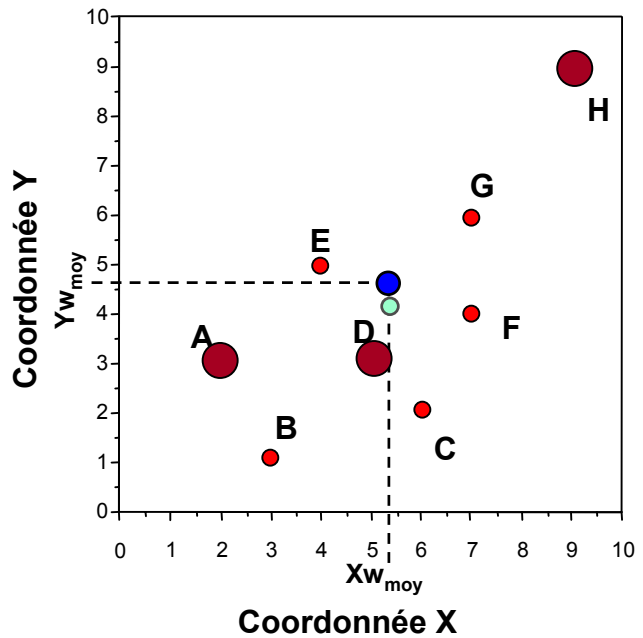
$\bar{X}_w = 91 / 17 = 5.343$

$\bar{Y}_w = 78 / 17 = 4.588$

Comment:

Compared with the mean center, the weighted mean center is slightly displaced toward H point

Weighted mean center



Point features : Global index of weighted dispersion

Based on the combined dispersion of X and Y coordinates, weighted feature's properties

- **Weighted standard distance SD_w :**

$$DS_w = \sqrt{\frac{\sum_{i=1}^{n} w_i (x_i - \bar{x})^2 + \sum_{i=1}^{n} w_i (y_i - \bar{y})^2}{\sum_{i=1}^{n} w_i}}$$

Modifier !

w_i = thematic value (weight) for point i

This is a measure of common dispersion in X and Y, with respect to the weighted mean center

Point features : Weighted standard distance

Computation

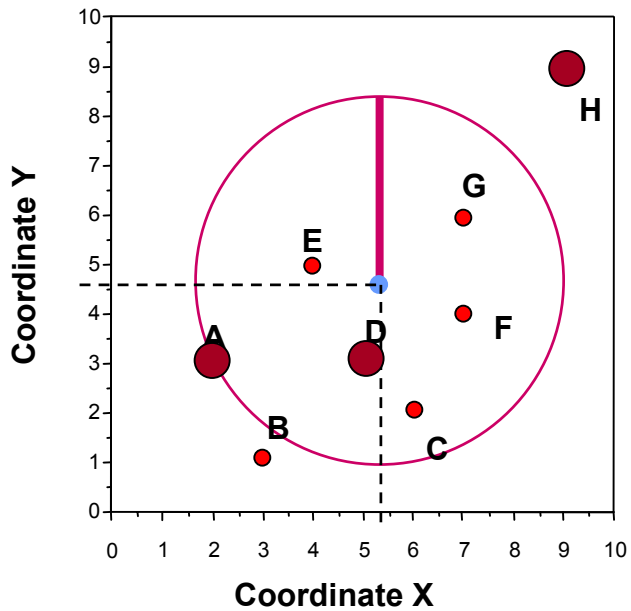
$$\frac{\sum_{i=1}^{n} w_i (x_i - \bar{x})^2}{\sum_{i=1}^{n} w_i} = 6.582$$

$$\frac{\sum_{i=1}^{n} w_i (y_i - \bar{y})^2}{\sum_{i=1}^{n} w_i} = 7.280$$

$SD_w = \sqrt{(6.582 + 7.28)}$

$SD_w = 3.723$

Weighted standard distance



Point features : Weighted neighborhood relationships

The most common neighborhood relationship is the measure of weighted proximity to features

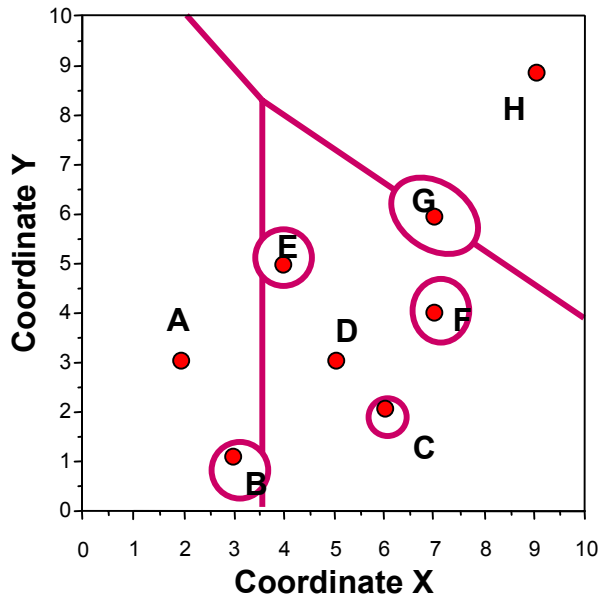
- **In object mode :**
  - **Areas of largest weighted proximity**
    - delimited by weighted equidistance line segments between points
    - they are polygones
- **In image mode :**
  - **The weighted distance to the nearest point region**
  - **Regions of largest weighted proximity**

Point objects : Areas of largest proximity

Properties

- The geometrical proximity to the 8 point features is weighted by their relative influence
- Any location within each area is closer to its center than to any other
- These areas of largest weighted proximity are called weighted Thiessen 's or Voronoï 's polygons

Areas of largest weighted proximity



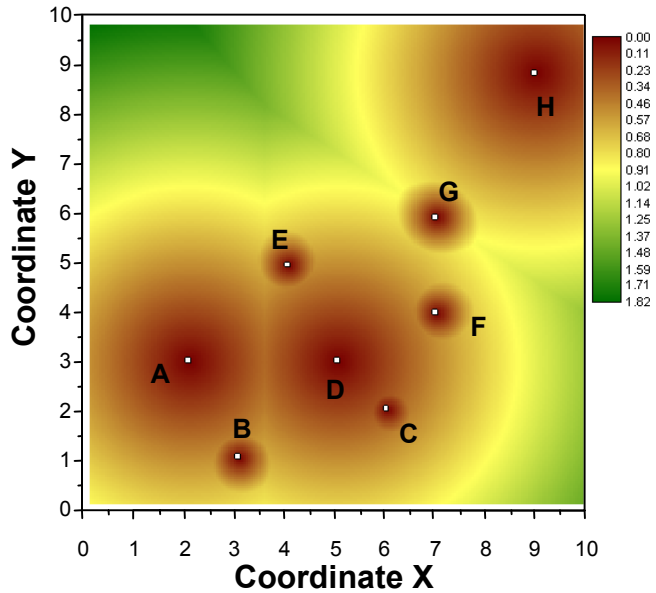
The geometrical proximity is weighted by their relative influence

Point regions : Weighted minimum distance

Properties

- Weighted distance image from each cell to the nearest point region, the weighted minimum distance
- The graphical representation suggests limits of areas of largest weighted proximity
- Image values express the proximity (weighted distance) to the nearest point region, but without identifying it !

Weighted minimum distance



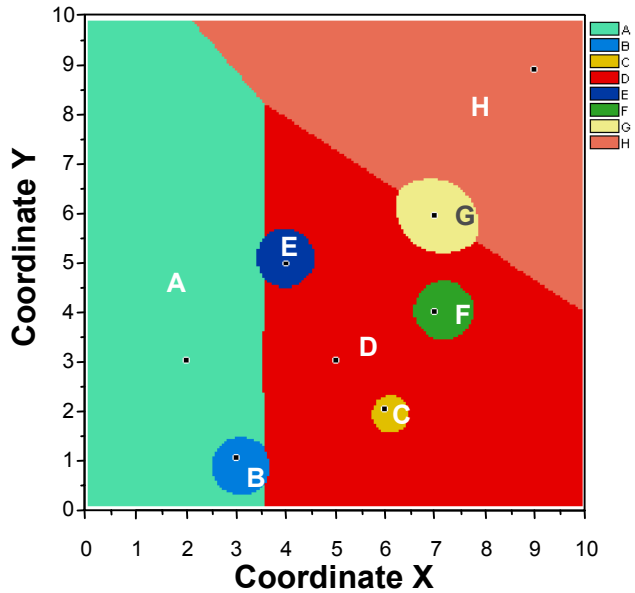
Maximum of minimum distances: 1.82
Mean of minimum distances: 0.71

Point regions : Regions of largest weighted proximity

Properties

- Image cells are assigned to the point region with the largest weighted proximity
- Space is divided into areal regions of largest weighted proximity to their center
- Image values identify the point region having the largest weighted proximity. This information adds to the distance value computed above

Regions of largest weighted proximity



Attribution to the closest point region

3 Weighted neighborhood of linear features

Linear features: Weighted spatial neighborhood

Different indicators for the spatial relationships of linear features

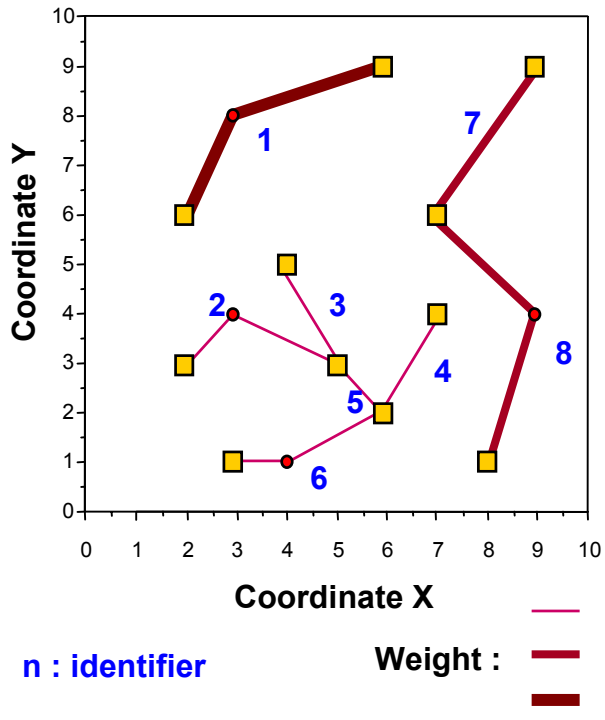
- **Neighborhood relationships description:**
  - weighted distance to features
  - areas and regions of largest weighted proximity

Linear features: Example of a distribution

Thematic properties of features (weight)

Feature	Z (weight)
1	2
2	1
3	1
4	1
5	1
6	1
7	1.5
8	1.5

Spatial distribution of the 8 linear features

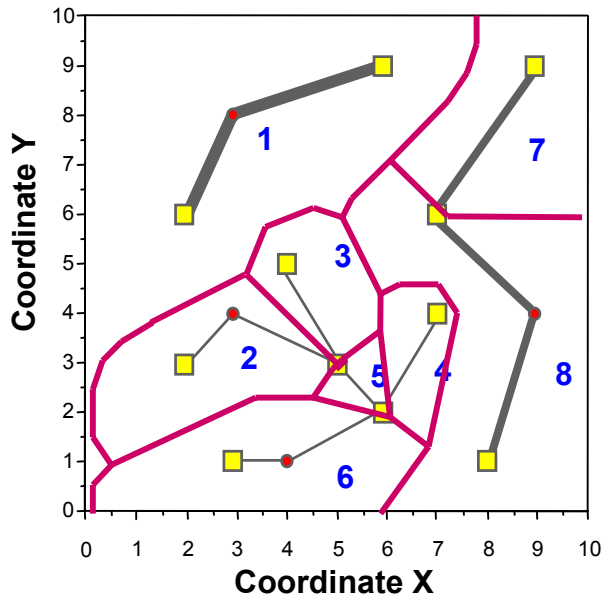


Linear objects: Areas of largest weighted proximity

Properties

- The space is divided into areas with the largest weighted proximity to each linear feature
- Any location within each area is closer to its linear feature than any other
- These areas of largest weighted proximity can be associated to the previously presented Thiessen's or Voronoï 's polygons

Areas of largest proximity



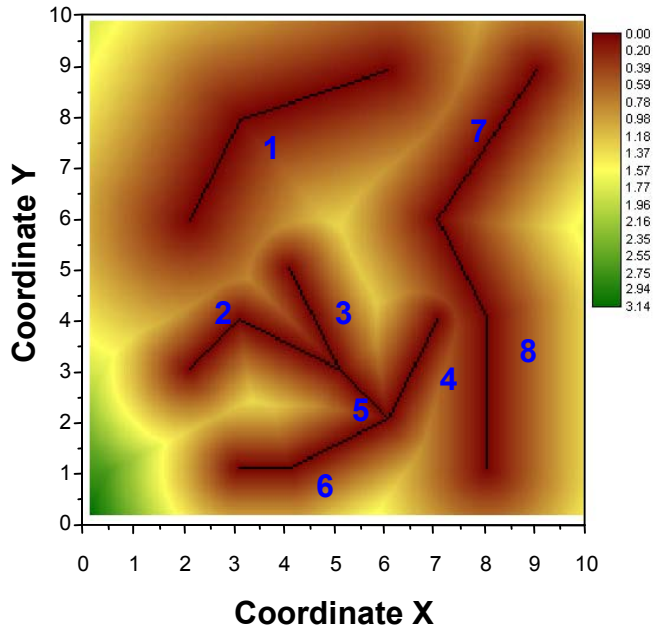
The geometrical proximity is weighted by the relative influence of objects

Linear regions: Weighted minimum distance

Properties

- Weighted distance image from each cell to the nearest linear region, the weighted minimum distance
- The graphical representation suggests limits of areas of largest weighted proximity
- Image values express the proximity (weighted distance) to the nearest linear region, but without identifying it !

Weighted minimum distance



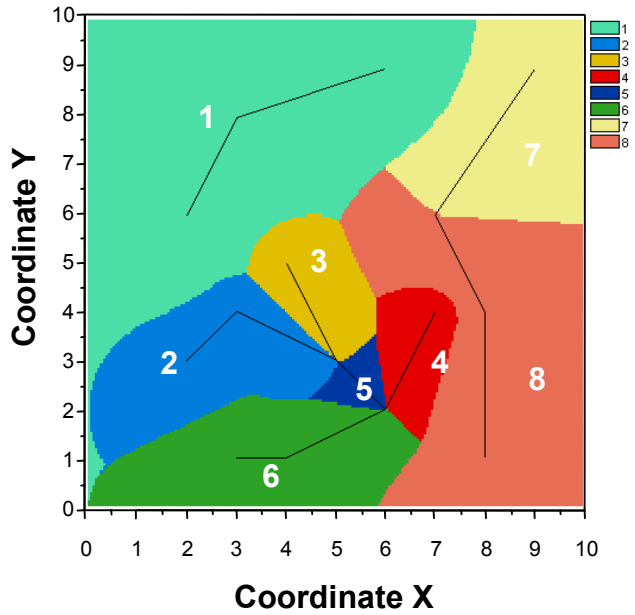
Maximum of minimum distances: 3.14
Mean of minimum distances: 0.66

Linear regions: Regions of largest weighted proximity

Properties

- Image cells are assigned to the linear region with the largest weighted proximity
- Space is divided into areal regions of largest weighted proximity to their linear feature
- Image values identify the linear region having the largest weighted proximity. This information adds to the distance value computed above

Regions of largest weighted proximity



Attribution to the closest linear region

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Weighted spatial neighborhood of areal features

Areal features: Weighted spatial neighborhood

Different indicators for the spatial relationships of areal features

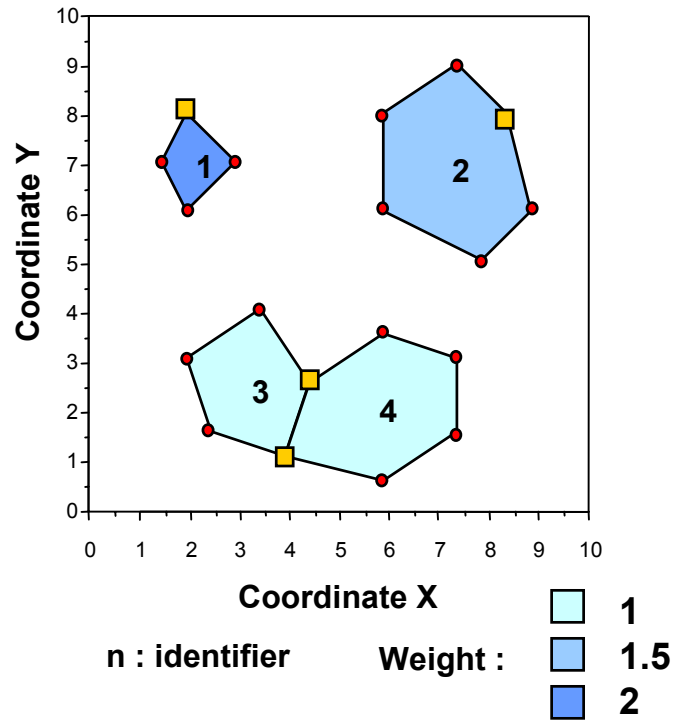
- **Neighborhood relationships description:**
  - weighted distance to areal features
  - areas and regions of largest weighted proximity

Areal features: Example of a distribution

Thematic properties of features (weight)

Feature	Z (weight)
1	2
2	1.5
3	1
4	1

Spatial distribution of the 4 areal features with their weight

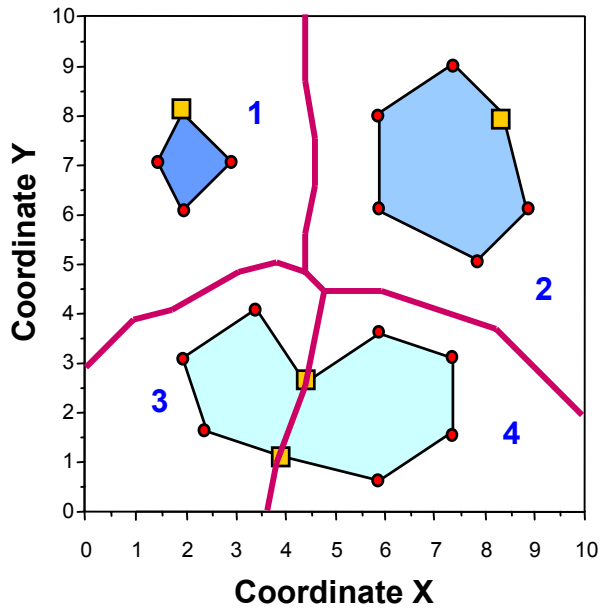


Areal objects: Areas of largest weighted proximity

Properties

- The geometrical proximity to the 4 areal objects is weighted by their relative influence
- Any location within each area is closer to its areal feature than to any other
- These areas of largest weighted proximity are often called Thiessen's or Voronoï 's polygons

Areas of largest weighted proximity



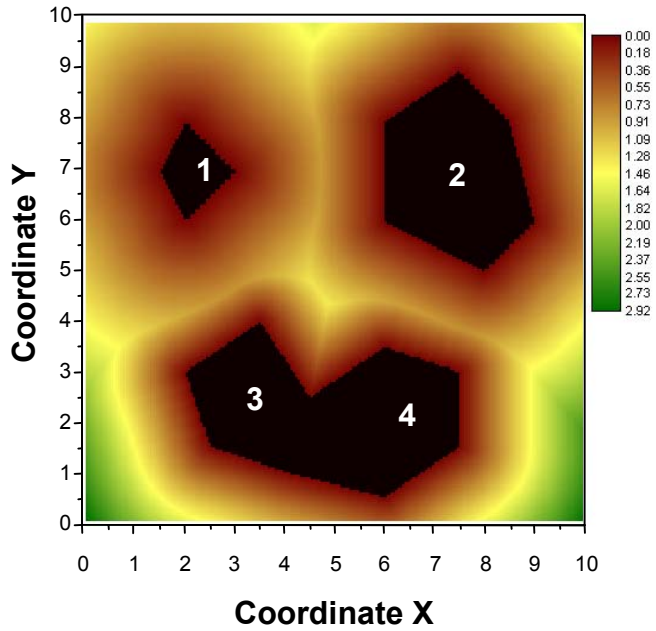
Areas of largest weighted proximity to the 4 areal features

Areal regions: Weighted minimum distance

Properties

- Weighted distance image from each cell to the nearest areal region, the weighted minimum distance
- The graphical representation suggests limits of areas of largest weighted proximity
- Image values express the proximity (weighted distance) to the nearest areal region, but without identifying it !

Weighted minimum distance



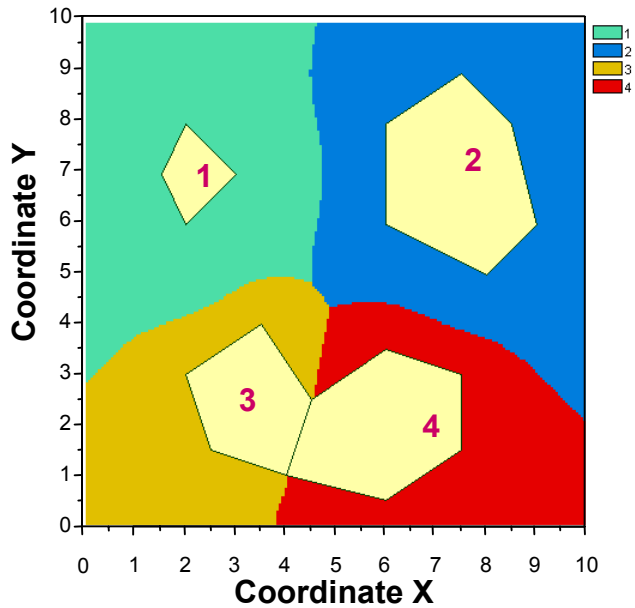
Maximum of minimum distances: 2.92
Mean of minimum distances: 0.61

Areal regions: Regions of largest weighted proximity

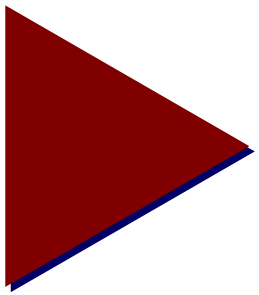
Properties

- Image cells are assigned to the areal region with the largest weighted proximity
- Space is divided into areal regions of largest weighted proximity to their areal feature
- Image values identify the areal region having the largest weighted proximity. This information adds to the distance value computed above

Regions of largest proximity



Attribution to the closest areal region of weighted proximity



End of Unit