Spatial Analysis and Modeling (GIST 4302/5302)

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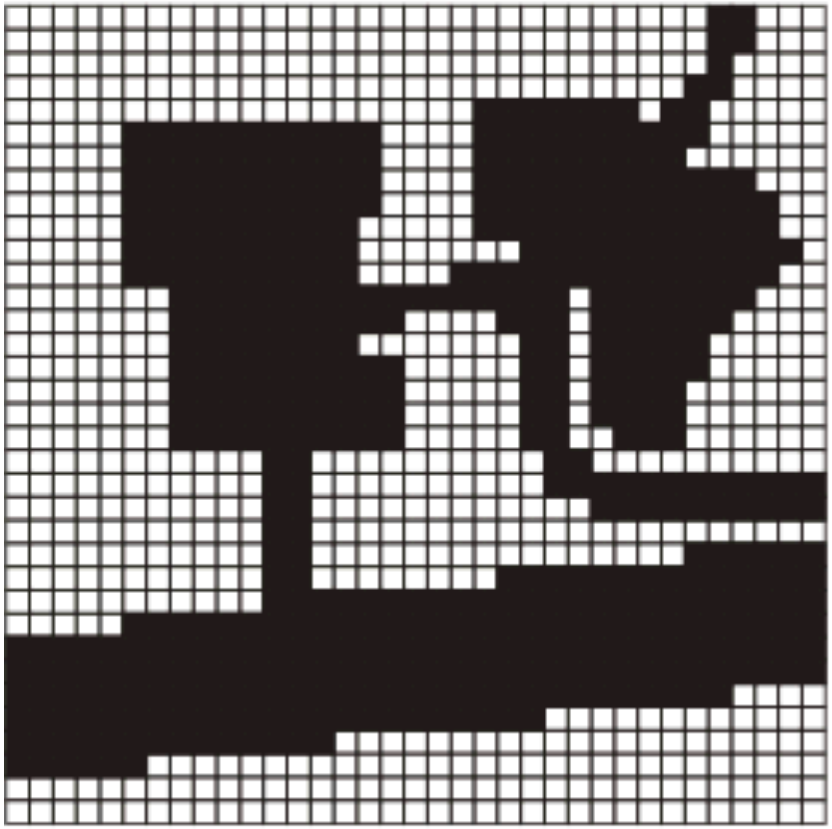
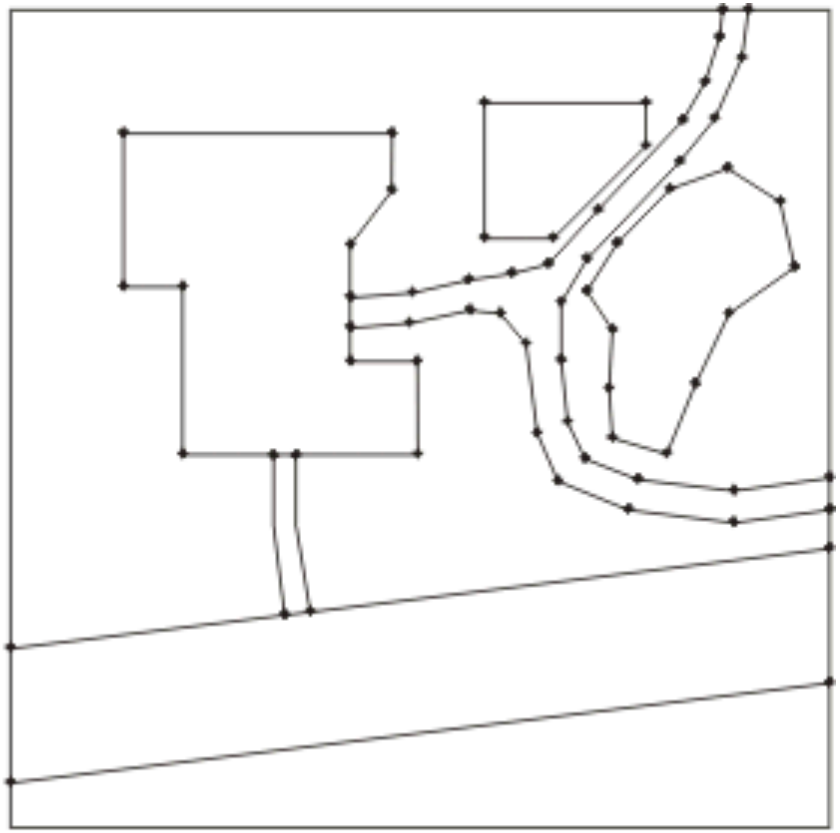
Representation of Spatial Data

Representation of Spatial Data Models

- ***Object-based model:*** treats the space as populated by discrete, identifiable entities each with a geospatial reference
  - Buildings or roads fit into this view
  - GIS Softwares: ArcGIS
- ***Field-based model:*** treats geographic information as collections of spatial distributions
  - Distribution may be formalized as a mathematical function from a spatial framework to an attribute domain
  - Patterns of topographic altitudes, rainfall, and temperature fit neatly into this view.
  - GIS Software: Grass



Raster



Vector

Field-based Approach

Spatial fields

- If the spatial framework is a Euclidean plane and the attribute domain is a subset of the set of real numbers;
  - The Euclidean plane plays the role of the horizontal xy-plane
  - The ***spatial field*** values give the z-coordinates, or "heights" above the plane

Regional Climate Variations

Imagine placing a square grid over a region and measuring aspects of the climate at each node of the grid. Different fields would then associate locations with values from each of the measured attribute domains.

Properties of the attribute domain

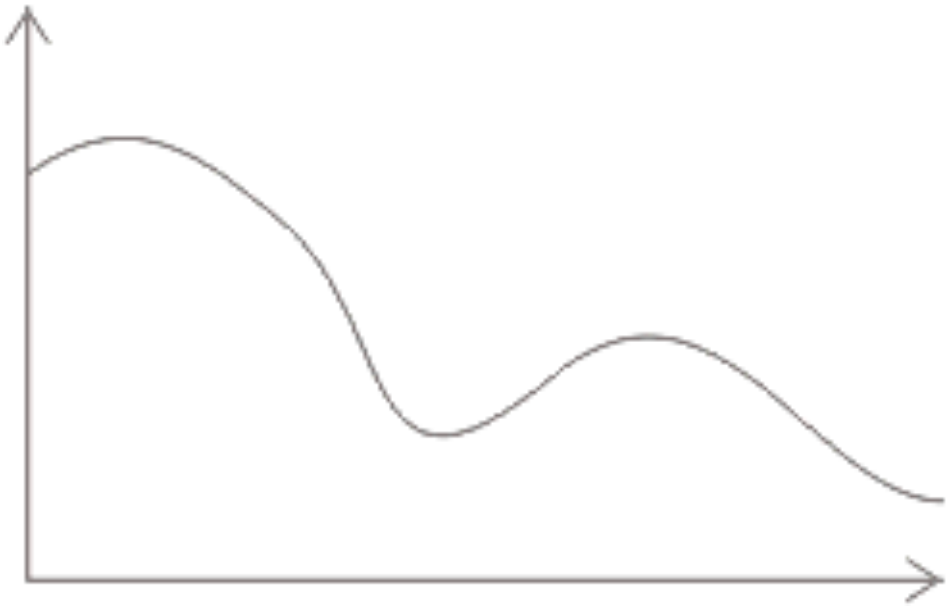
- The attribute domain may contain values which are commonly classified into four levels of measurement
  - ***Nominal attribute***: simple labels; qualitative; cannot be ordered; and arithmetic operators are not permissible
  - ***Ordinal attribute***: ordered labels; qualitative; and cannot be subjected to arithmetic operators, apart from ordering
  - ***Interval attributes***: quantities on a scale without any fixed point; can be compared for size, with the magnitude of the difference being meaningful; the ratio of two interval attributes values is not meaningful
  - ***Ratio attributes***: quantities on a scale with respect to a fixed point; can support a wide range of arithmetical operations, including addition, subtraction, multiplication, and division

Continuous and differentiable fields

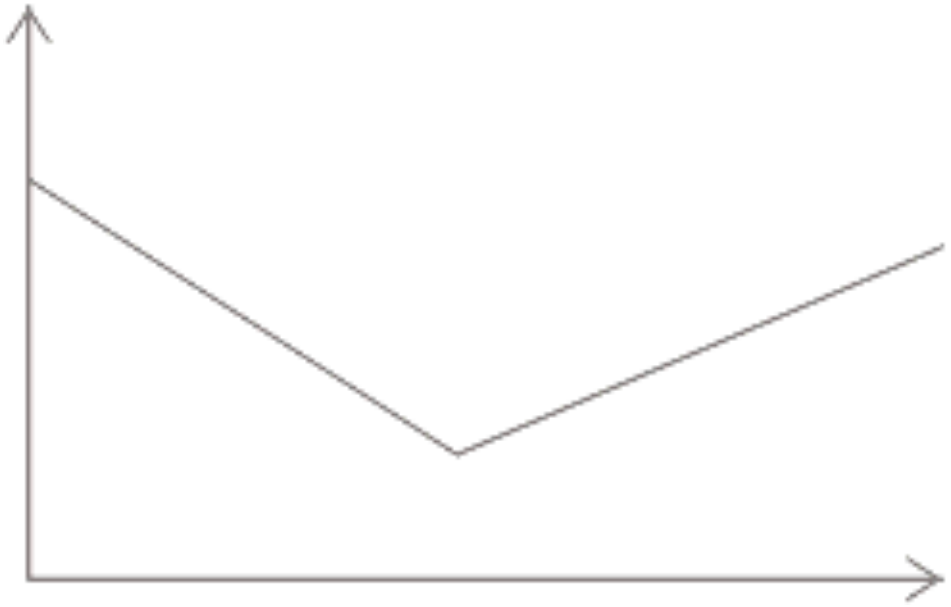
- ***Continuous*** field: small changes in location leads to small changes in the corresponding attribute value
- ***Differentiable*** field: rate of change (slope) is defined everywhere
- Spatial framework and attribute domain must be continuous for both these types of fields
- Every differentiable field must also be continuous, but not every continuous field is differentiable

One dimensional examples

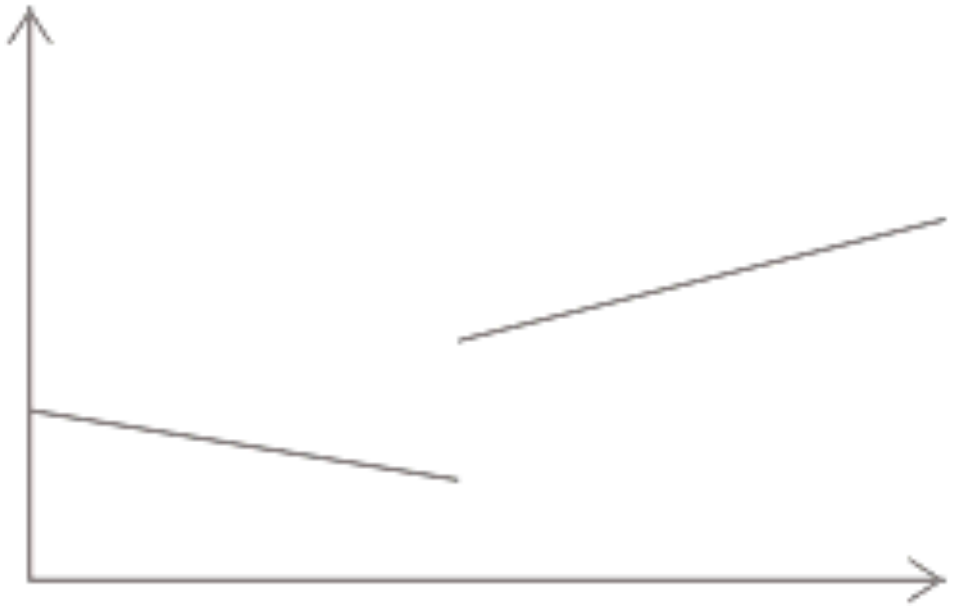
- Fields may be plotted as a graph of attribute value against spatial framework



One dimensional examples

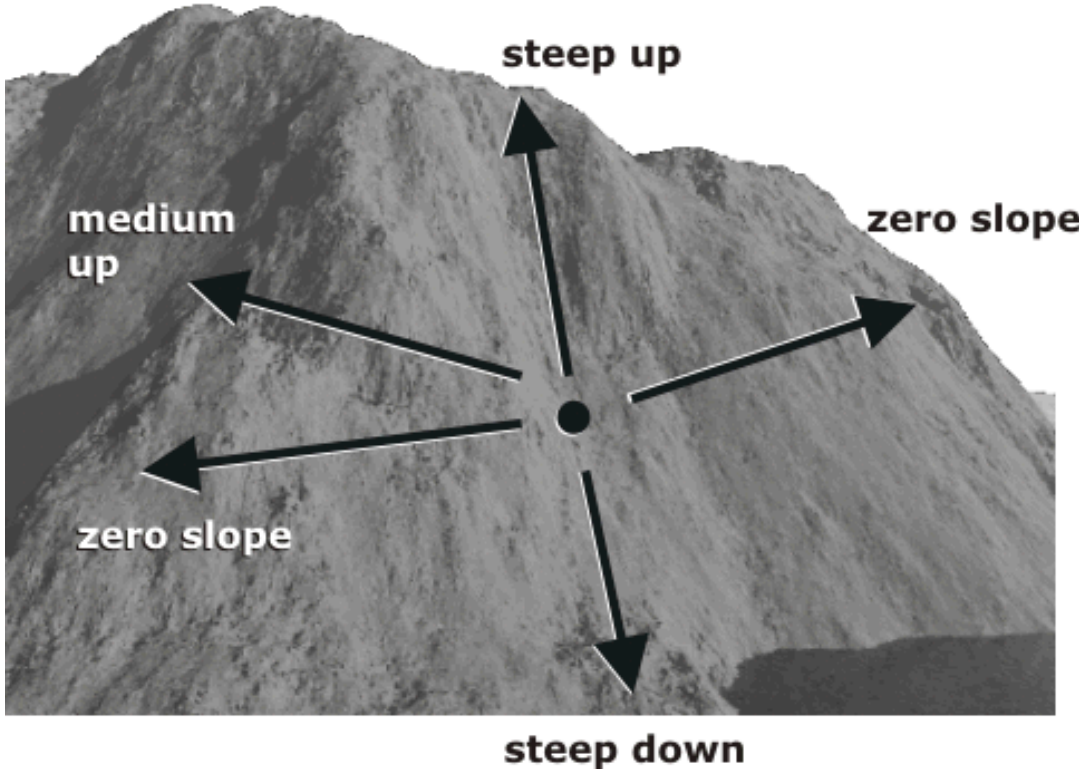


One dimensional examples



Two dimensional examples

- The slope is dependent on the particular location and on the bearing at that location

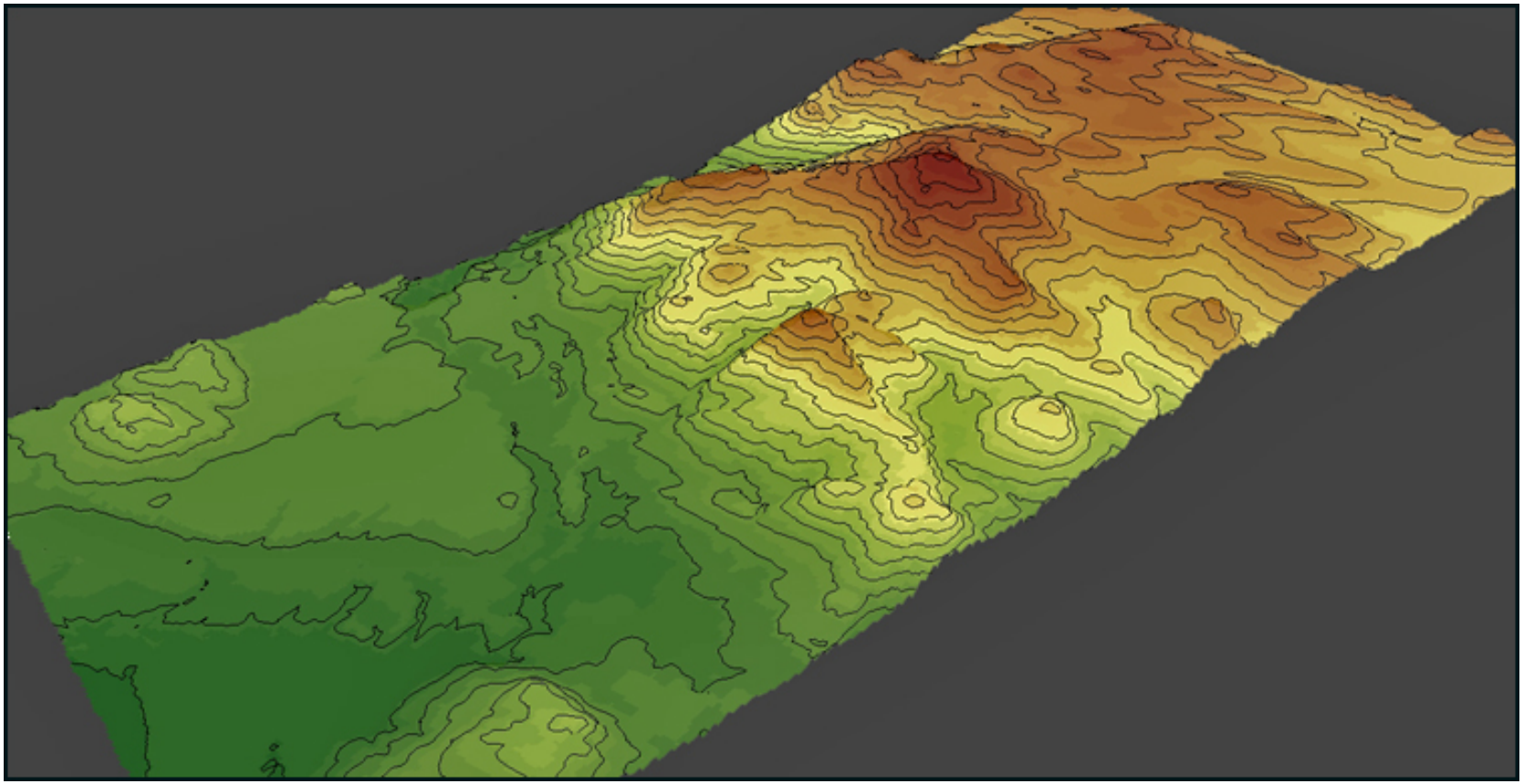


Representations of Spatial Fields

- Points
- Contours
- Raster/Lattice
- Triangulation (Delaunay Trangulation)

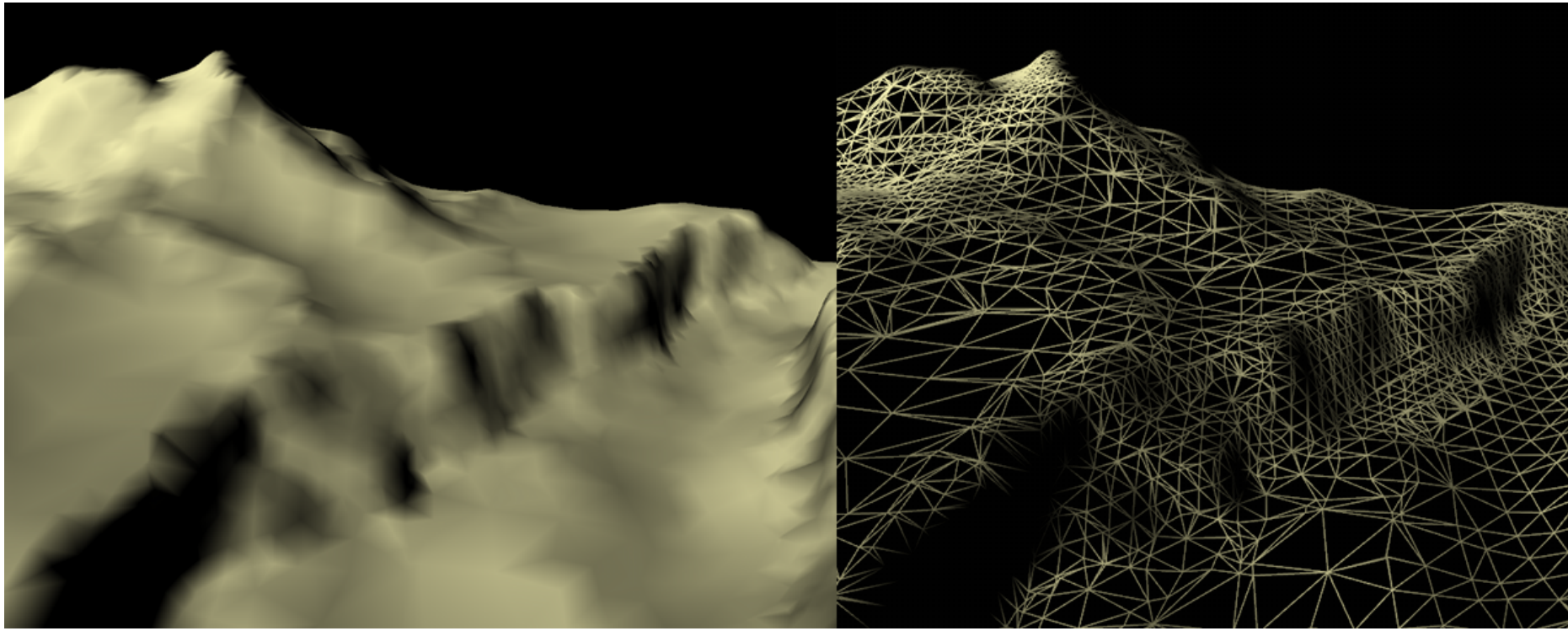
Example

- Contour lines and raster



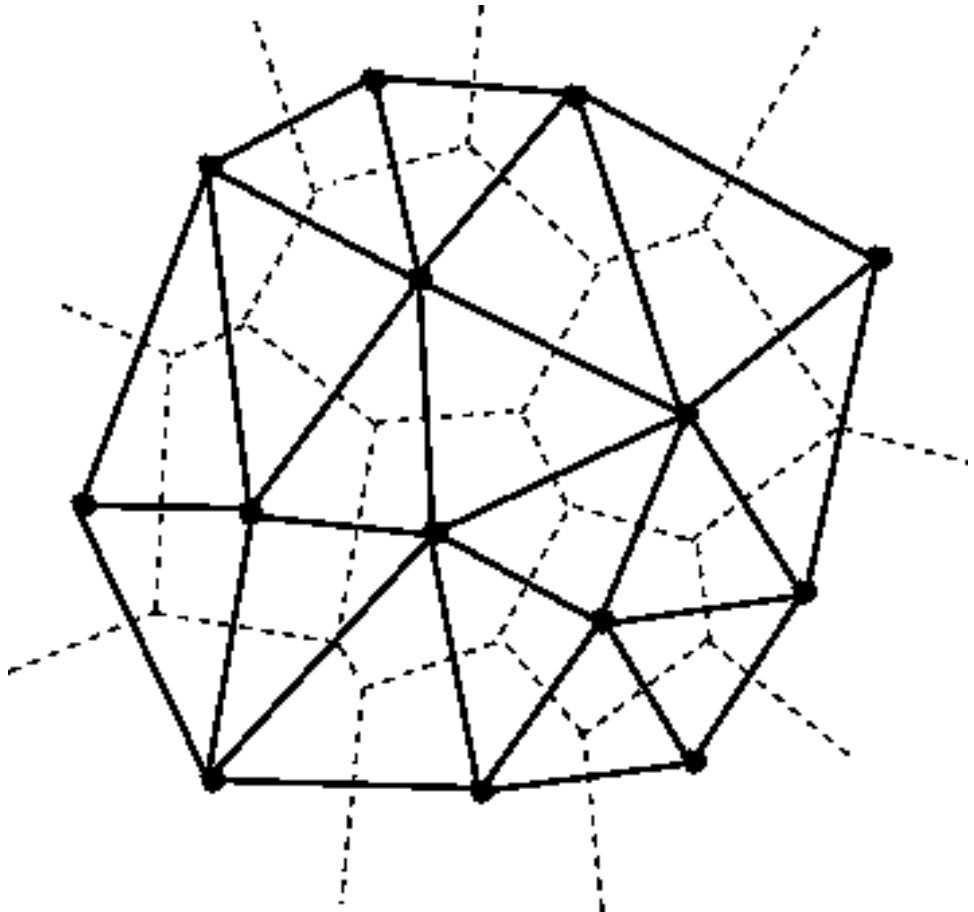
Example

- Trangulations



Side Note: Delaunay Triangulation and Voronoi Diagram

- Dual Graph

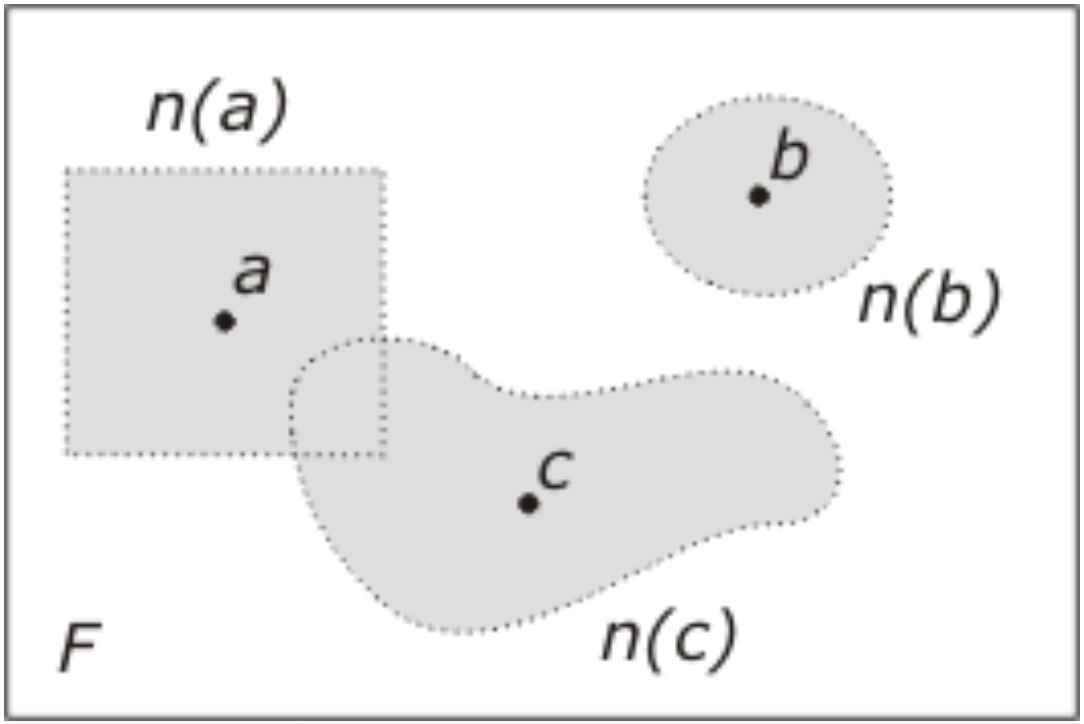


Operations on fields

- A field operation takes as input one or more fields and returns a resultant field
- The system of possible operations on fields in a field-based model is referred to as ***map algebra***
- Three main classes of operations
  - Local
  - Focal
  - Zonal

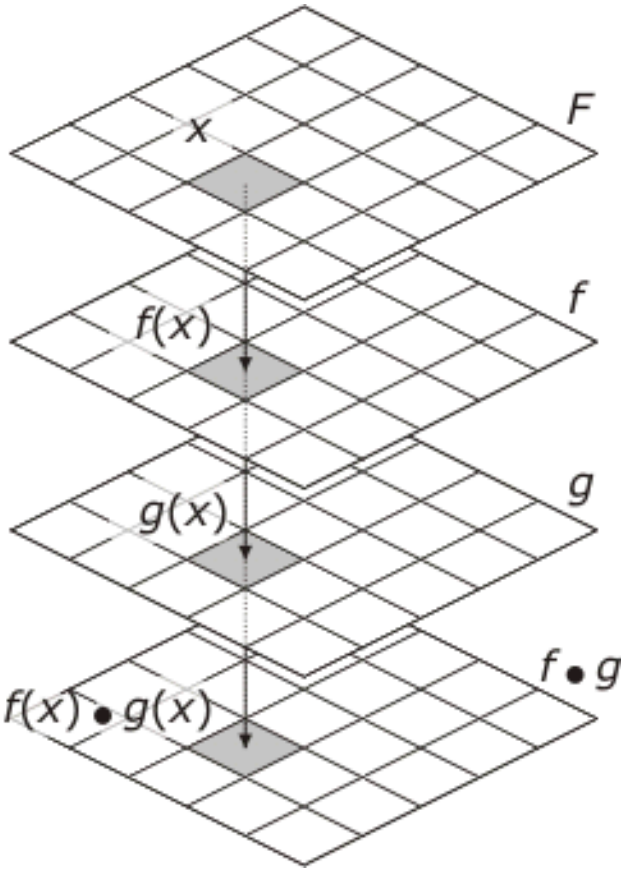
Neighborhood function

- Given a spatial framework *F*, a ***neighborhood function*** *n* is a function that associates with each location *x* a set of locations that are "near" to *x*



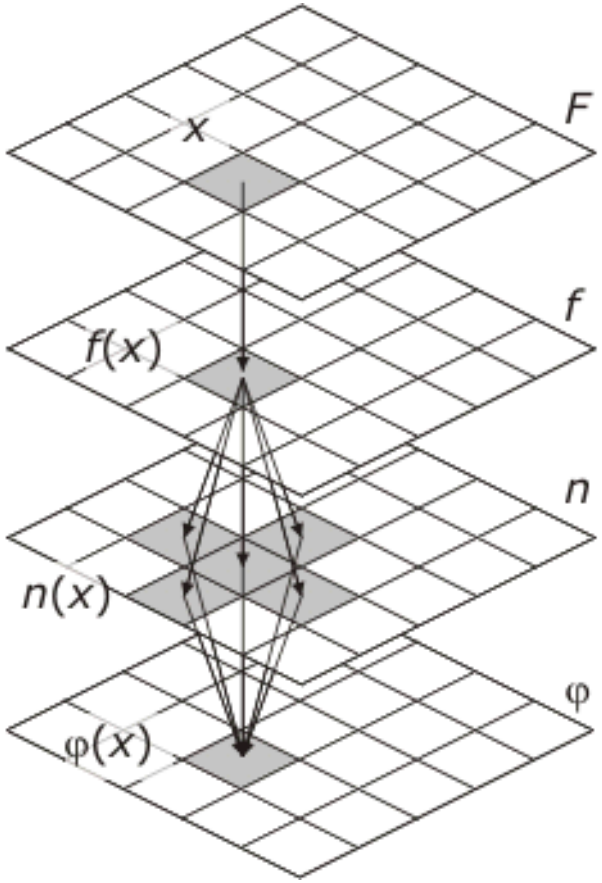
Local operations

- ***Local operation:*** acts upon one or more spatial fields to produce a new field
- The value of the new field at any location is dependent on the values of the input field function at that location
  - is any binary operation



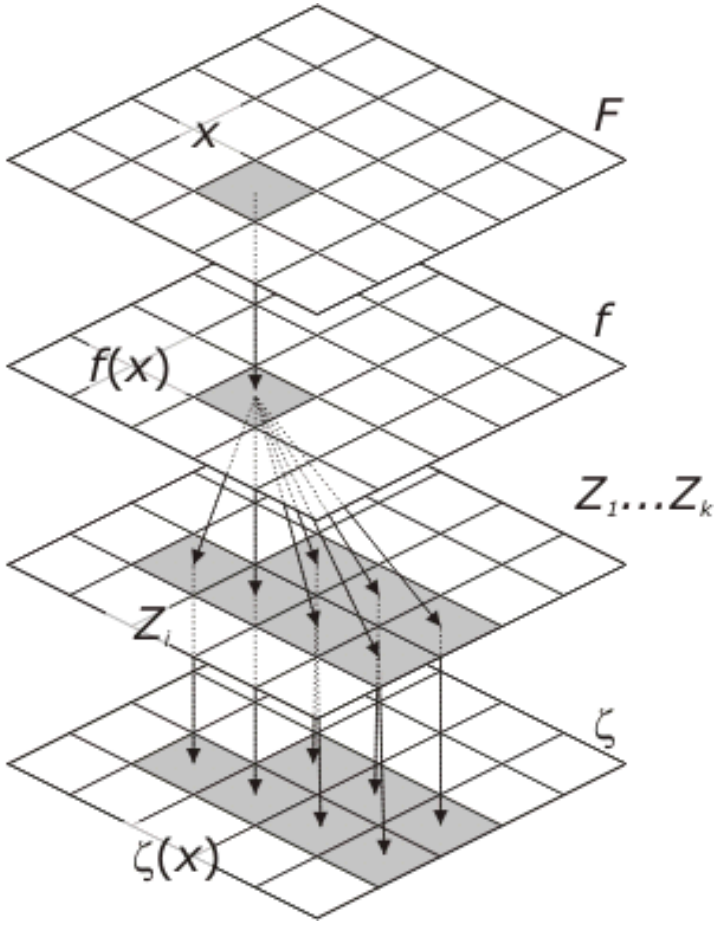
Focal operations

- ***Focal operation***: the attribute value derived at a location *x* may depend on the attributes of the input spatial field functions at *x* and the attributes of these functions in the neighborhood *n*(*x*) of *x*



Zonal operations

- ***Zonal operation***: aggregates values of a field over a set of zones (arising in general from another field function) in the spatial framework
- For each location *x*:
  1. Find the Zone Z_i in which *x* is contained
  2. Compute the values of the field function *f* applied to each point in Z_i
  3. Derive a single value $\zeta(x)$ of the new field from the values computed in step 2



Summary: Object-based vs Field-based models

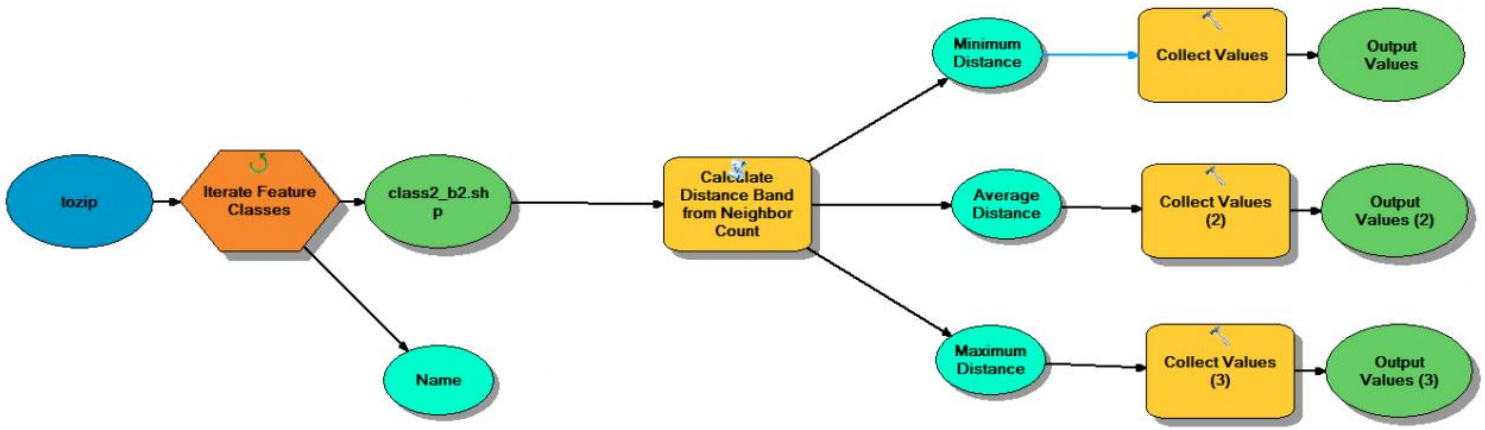
- Object-based models:
  - Greater precision
  - Less redundant information (smaller storage footprints)
  - Complex data structures
- Field-based models:
  - Simpler data structures
  - More redundant information (larger storage footprints)
  - Less precision
- *Raster is faster, but vector is corrector*

Raster <-> Vector

- Vector-> Raster
  - Interpolation
    - Inverse distance weighted, Kriging, Spline
  - Density surface
    - Kernel density
  - Rasterization
- Raster->Vector
  - Watershed
  - Vectorization (raster to polygon)
  - …

Model Builder

- Graphic Programming
- Reusable operations
- Streamline the workflow



- End of this topic