Aalto University
School of Arts, Design
and Architecture

MAR-E1004 Basics of GIS: From points to surfaces

Jaakko Madetoja
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Slides adopted from Kirsi Virrantaus, Paula Ahonen-Rainio & Salla Multimäki

Learning goals

In this session you will learn

From surfaces to points

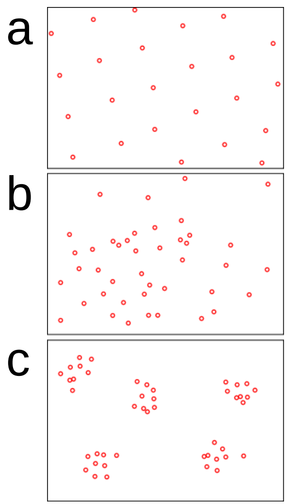
Simple: Use overlay with polygons or Sample tool (Spatial Analyst Tools -> Extraction -> Sample) with raster.

From a set of points to a surface

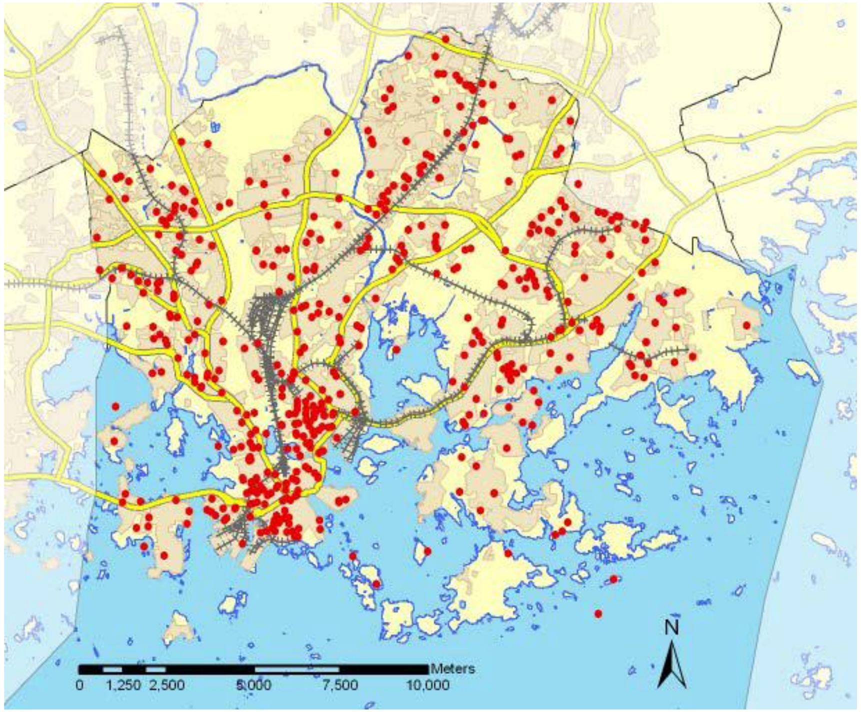
- **Density surface**
  - Kernel density

- **Spatial interpolation**
  - Thiessen polygons (cf. Voronoi diagram)
  - IDW
  - TIN

Case: Incidents of domestic fire in Helsinki

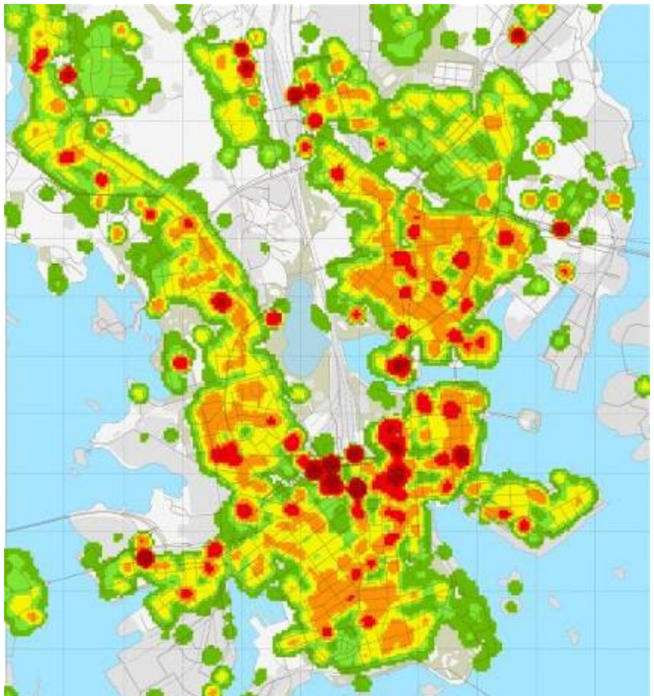


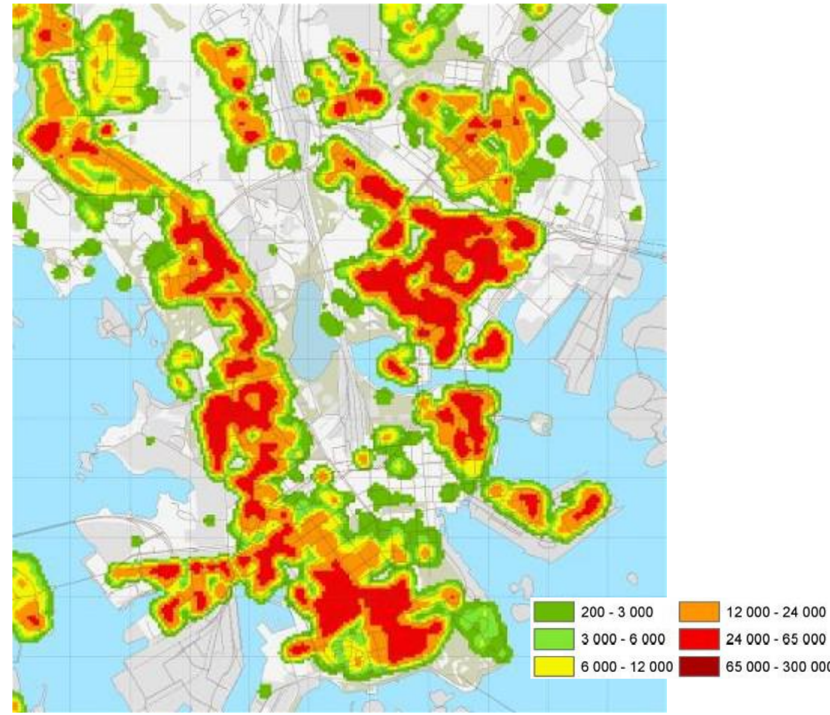
The distribution of the events is not regular (a) nor random (b)



Spatenkova 2009

Case: Incidents of domestic fire in Helsinki





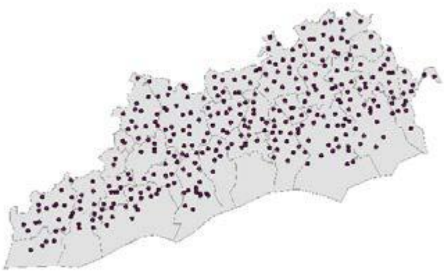
Spatenkova 2009

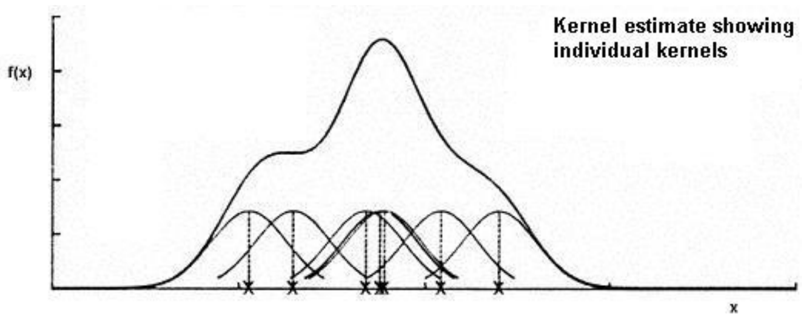
Kernel density estimation

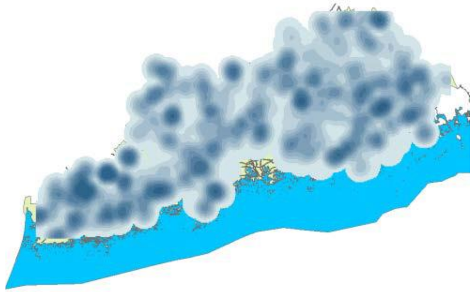
- **Transformation from point objects to a density surface to visualize a point pattern to detect hot spots where the local density is estimated to be high**
- **to allow comparison of point data with a surface variable**
- **Density at any location in the study area**
  - estimated by counting the number of objects (or events) in a region (=kernel) centered at the location p where the estimate is made
- **Simple kernel: circle centered at the location p**
- **More sophisticated: a kernel function weighting nearby events**
- **Complexity: density is scale-dependent! (cf. kernel bandwidth)**

Kernel density surface

- **Kernel function (e.g., bell shape) for the local density**
  - Each point is replaced by a kernel
  - Density surface is the sum of these







Krisp 2006

Kernel density surface

Kernel *bandwidth* affects the resulting density surface

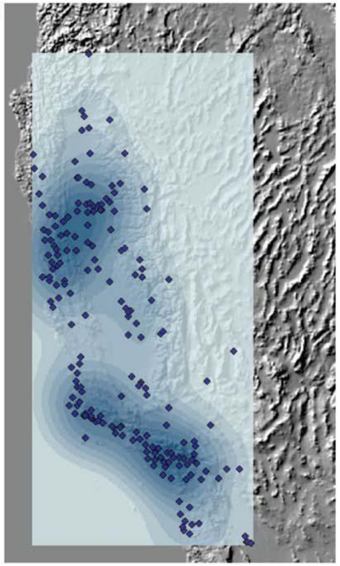
- Large bandwidth results to smooth variation, densities get close to the global average across the study area
- Small bandwidth results to surface pattern focusing strongly to individual events and zero densities between remote events

Example: Density estimation using two different distance parameters in the respective kernel functions.

(A) the surface shows the density of ozone-monitoring stations in California, using a kernel radius of 150 km

(B) zoomed to an area of Southern California, a kernel radius of 16 km is too small for this dataset, as it leaves each kernel isolated from its neighbors

(A)

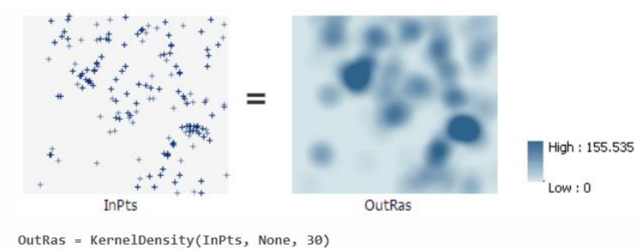


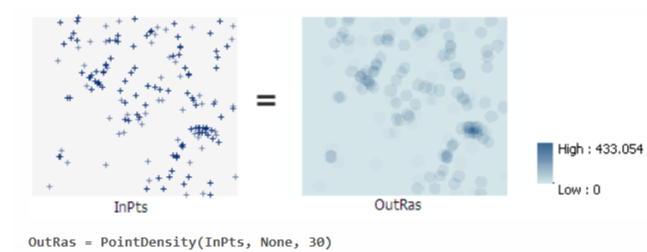
(B)

Longley et al.

Kernel density in ArcMap

- **Use the fire and rescue mission dataset from session 2 (prontodata)**
- **Analyze the density of these missions in Helsinki using Kernel and Point Density tools in Spatial Analyst Tools -> Density**





Density surface and spatial interpolation

Density surface estimates the variation of the density of discrete events (events = point objects)

- Population of known cities

Spatial interpolation predicts the values of a spatially continuous variable at unsampled locations from the measurements (known values) made at control points (sample points) in the same area

- Temperature in measurement points

Spatial interpolation

Values of a field measured at a number of sample points

$\Rightarrow$ need to estimate the continuous field

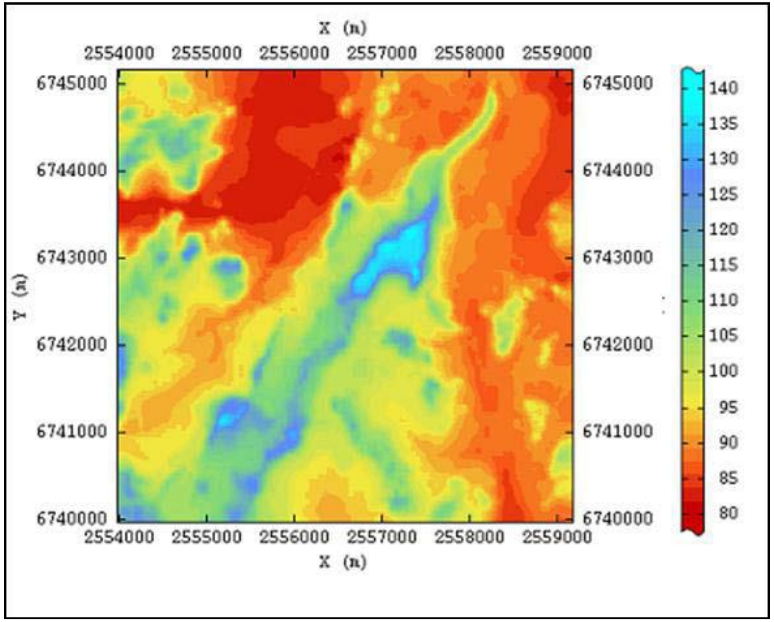
i.e. values at points where the field was not measured (points to be estimated)

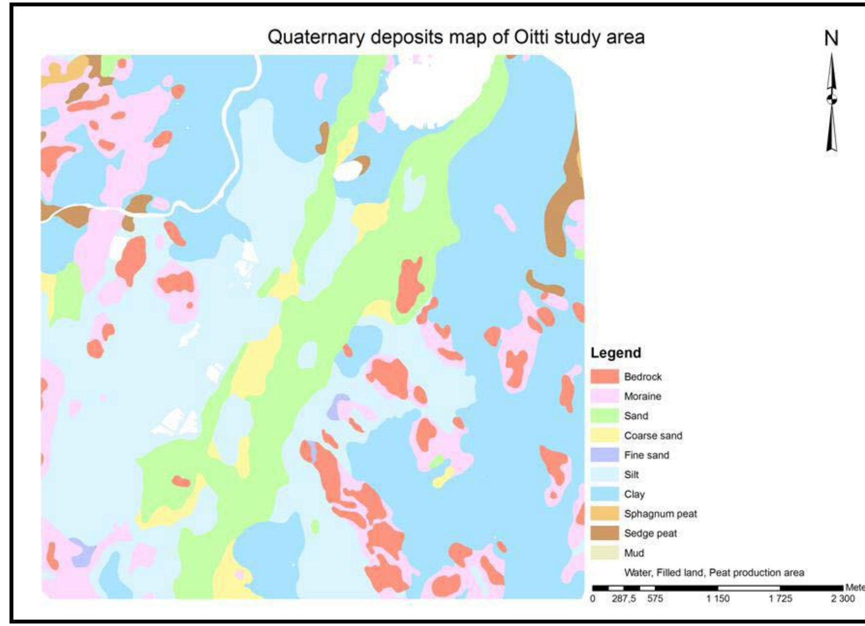
Interpolation is not possible without positive spatial autocorrelation: locations close to each other are more similar than locations far away

Which method?

- Characteristics of the represented phenomenon
- Continuos or categorized values

Continuous or categorical data





Sunila 2009

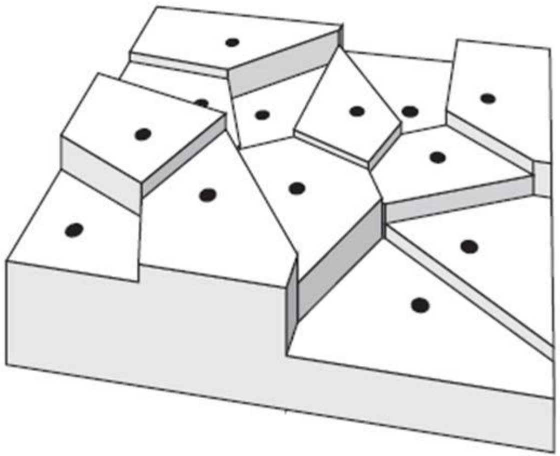
Methods for spatial interpolation

- **Thiessen polygons: nearest value method**
- **TIN model: linear interpolation on the planes of triangles**
- **IDW: Inverse distance weighted spatial average**

Thiessen polygons

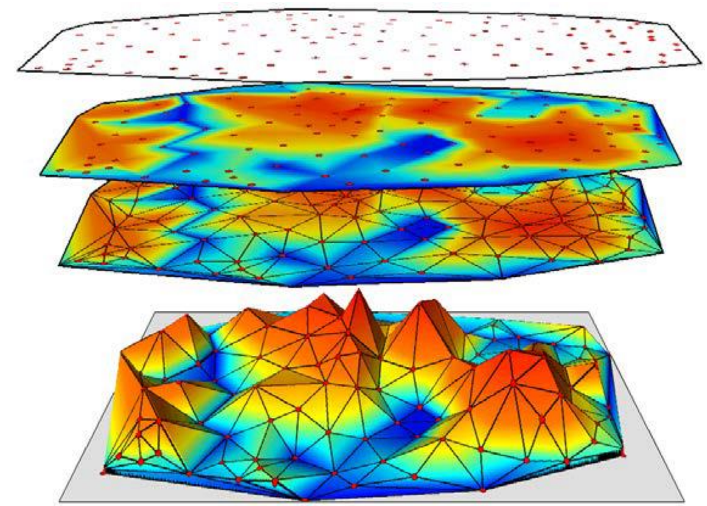
Every unsampled point gets the value of its nearest control point

- **Proximity polygon of a [control] point: that region of the space which is closer to this point than any other**
- **Abrupt changes in adjacent polygons**
  - May suit well for some phenomena, and not at all for others
  - The approach is quite obvious when visualized; no wrong expectations of the accuracy
- **Useful for nominal data**
  - But may not be considered interpolation in these cases (rather a transformation)



TIN represents the surface *per se*

- **Sample points are connected to form triangles**
- **The field inside each triangle is represented as a plane**
  - The value of the variable (i.e. the field) at any location p inside the triangle can be calculated from the values at the vertices and the distances from the location p to the vertices



www.geosolutions.com

Inverse distance weighted spatial average = IDW

Nearer locations are considered more prominent

-> the values of sample points around the point to be interpolated are weighted according to the inverse distance

- for example, $w=1/d^2$ (decreases the effect of more distance points)
- weights at any interpolated point shall sum to 1