COA 690/790 GIS in Marine Science

Lecture 9
Spatial Interpolation

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INTERPOLATION

Procedure to predict values of attributes at unsampled points

Why?
Can't measure all locations:
- Time
- Money
- Impossible (physical- legal)

Changing cell size

Missing/unsuitable data

Past date *(eg. temperature)*

Systematic sampling pattern

Easy
Samples spaced uniformly at fixed X, Y intervals
Parallel lines

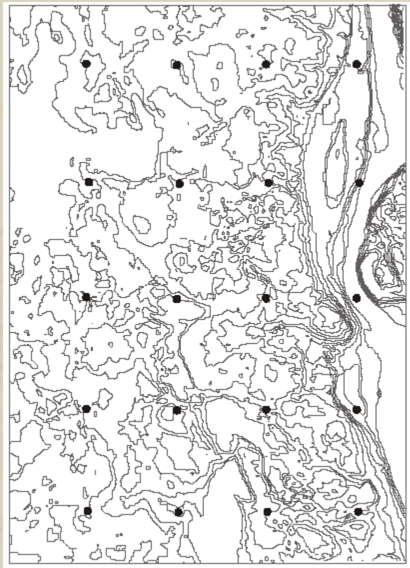
Advantages

Easy to understand

Disadvantages

All receive same attention
Difficult to stay on lines

May be biases



Random Sampling

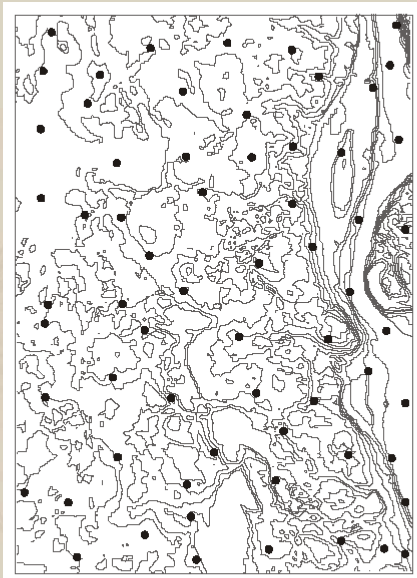
Select point based on random number process
Plot on map
Visit sample

Advantages

Less biased *(unlikely to match pattern in landscape)*

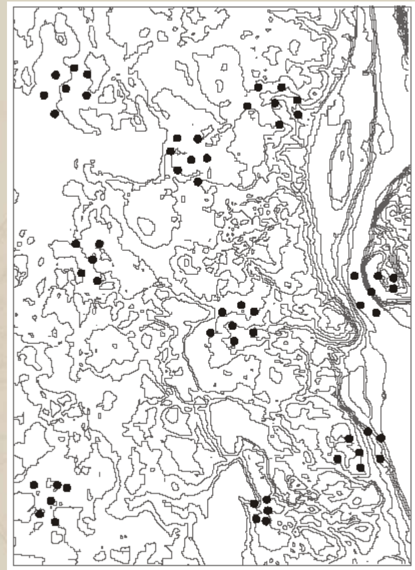
Disadvantages

Does nothing to distribute samples in areas of high
Difficult to explain, location of points may be a problem



Cluster Sampling

Cluster centers are established
(random or systematic)
Samples arranged around each center
Plot on map
Visit sample
(e.g. US Forest Service, Forest Inventory Analysis (FIA)
Clusters located at random then systematic pattern of samples at that location)

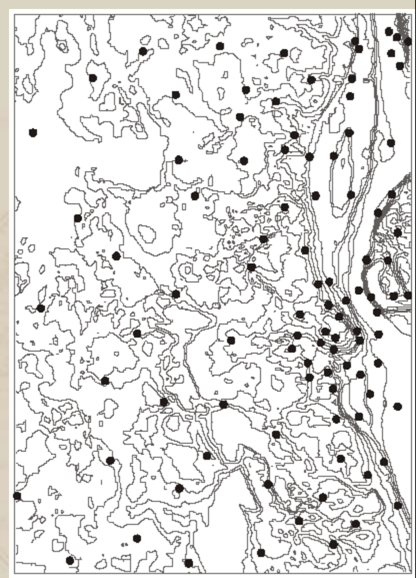


Advantages

Reduced travel time

Adaptive sampling

More sampling where there is more variability.
Need prior knowledge of variability, e.g. two stage sampling



Advantages

More efficient, homogeneous areas have few samples, better representation of variable areas.

Disadvantages

Need prior information on variability through space

INTERPOLATION

Many methods - All combine information about the sample coordinates with the magnitude of the measurement variable to estimate the variable of interest at the unmeasured location

Methods differ in weighting and number of observations used

Different methods produce different results

No single method has been shown to be more accurate in every application

Accuracy is judged by withheld sample points

INTERPOLATION

Outputs typically:

Raster surface

- *Values are measured at a set of sample points*
- *Raster layer boundaries and cell dimensions established*
- *Interpolation method estimate the value for the center of each unmeasured grid cell*

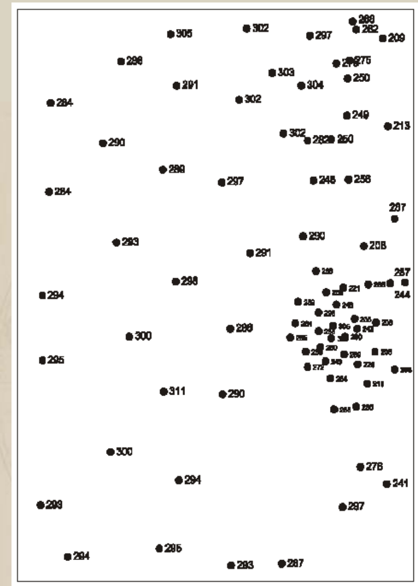
Contour Lines

Iterative process

- *From the sample points estimate points of a value Connect these points to form a line*
- *Estimate the next value, creating another line with the restriction that lines of different values do not cross.*

Example Base

Elevation contours



Sampled locations and values

INTERPOLATION

1st Method - Thiessen Polygon

Assigns interpolated value equal to the value found at the nearest sample location

Conceptually simplest method

Only one point used (nearest)

Often called nearest sample or nearest neighbor

INTERPOLATION

Thiessen Polygon

Advantage:
Ease of application

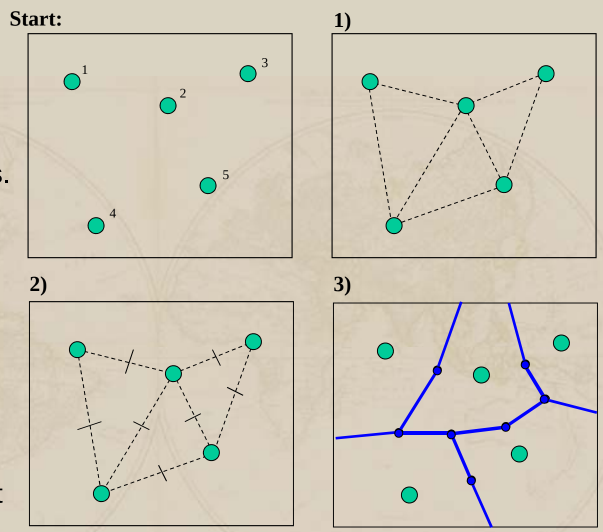
Accuracy depends largely on sampling density

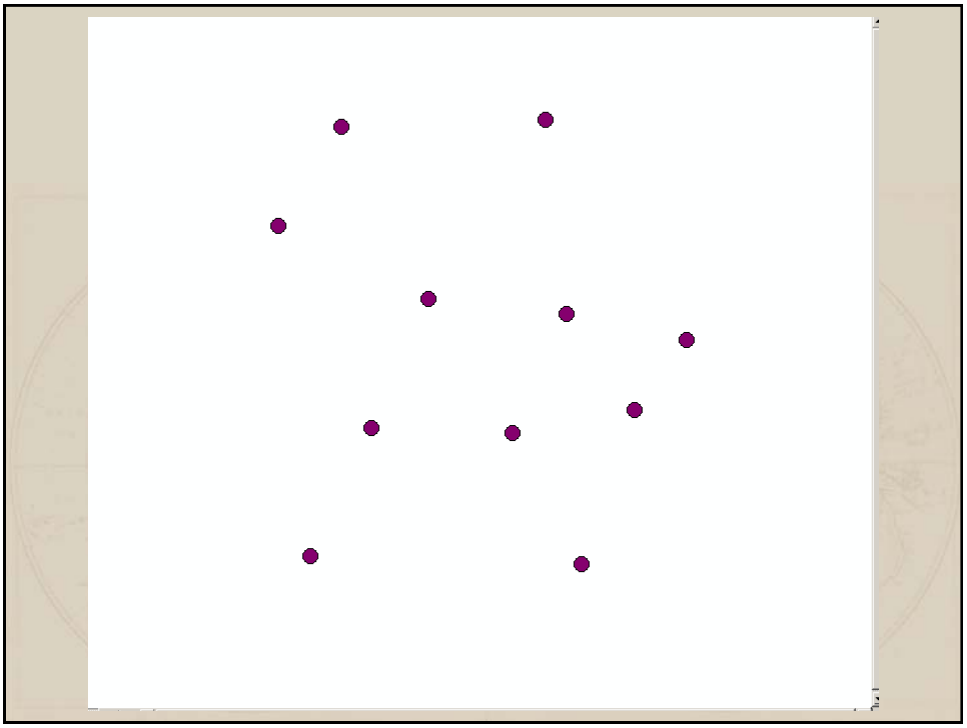
Boundaries often odd shaped as transitions between polygons
are often abrupt

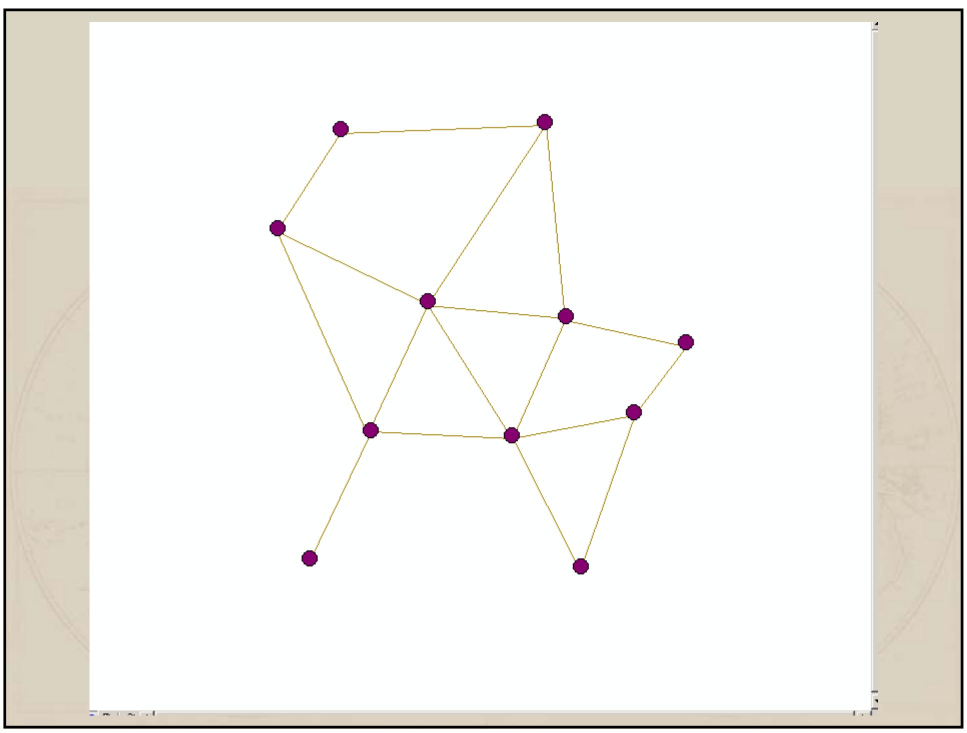
Continuous variables often not well represented

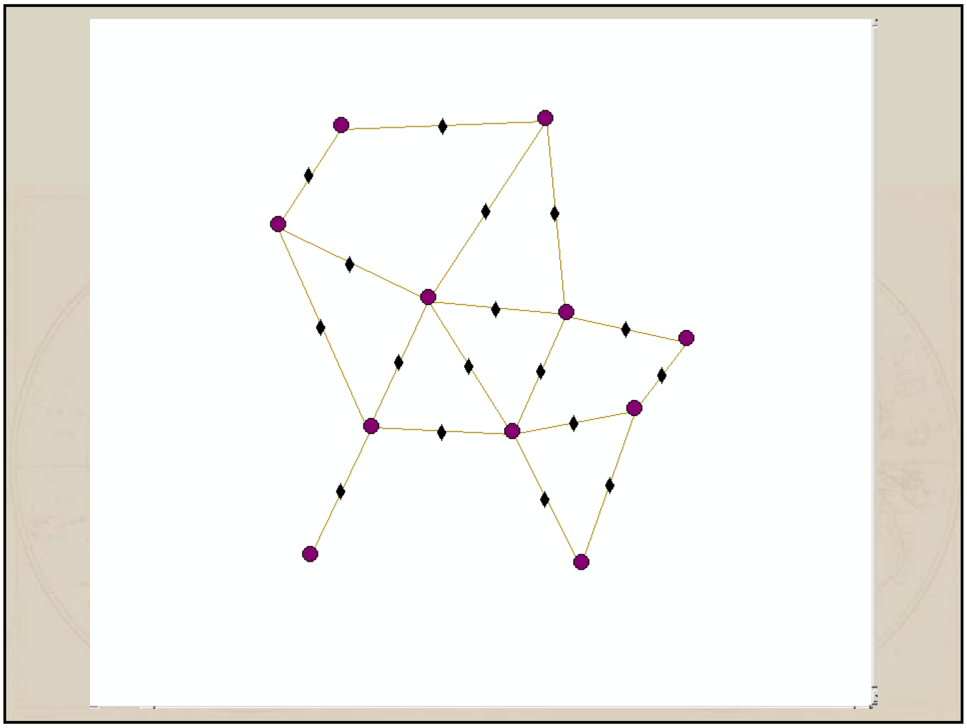
Thiessen Polygon

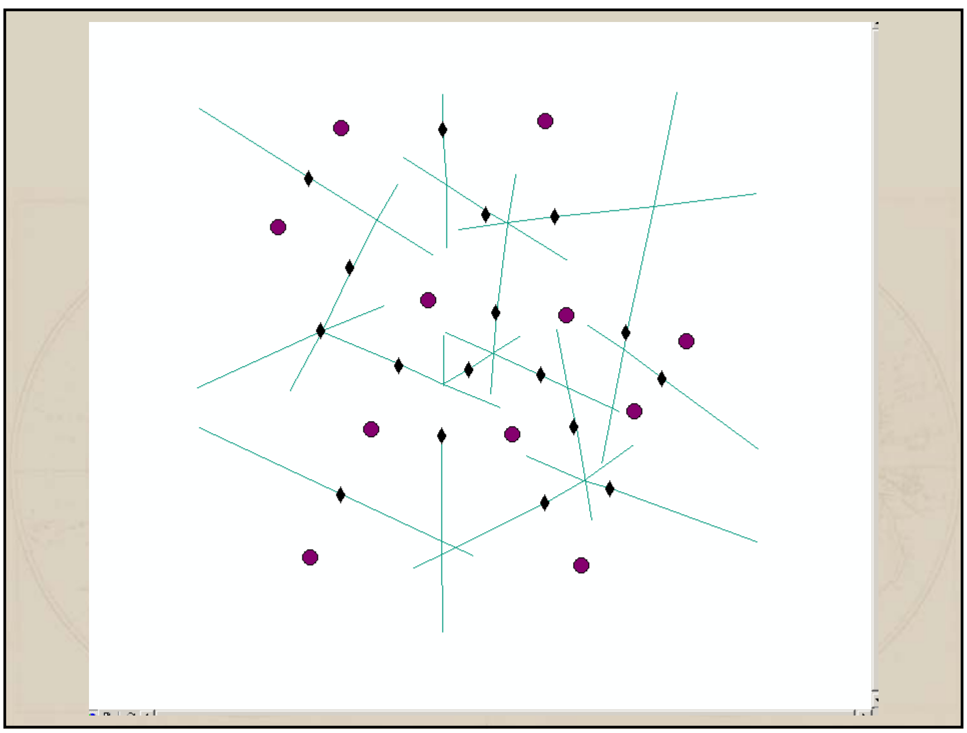
1. Draw lines connecting the points to their nearest neighbors.
2. Find the bisectors of each line.
3. Connect the bisectors of the lines and assign the resulting polygon the value of the center point

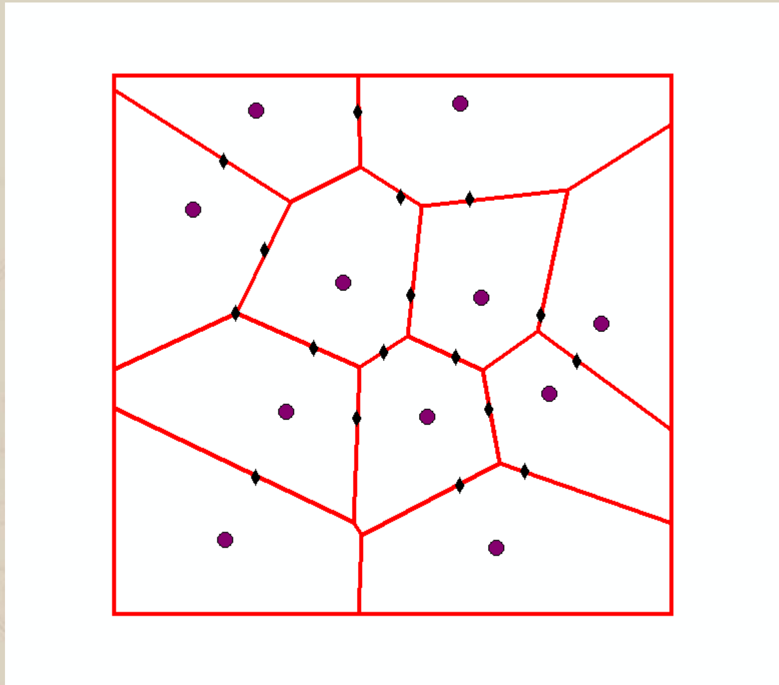


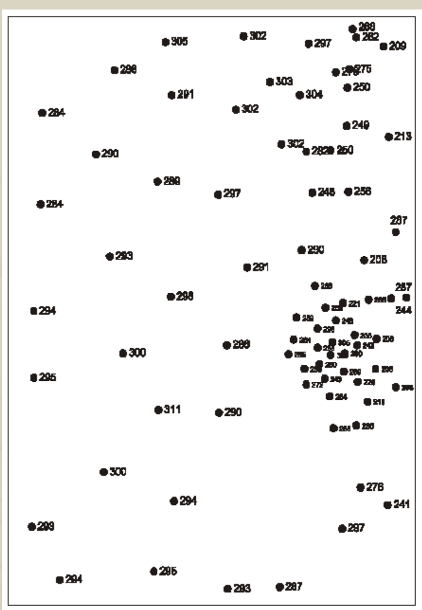




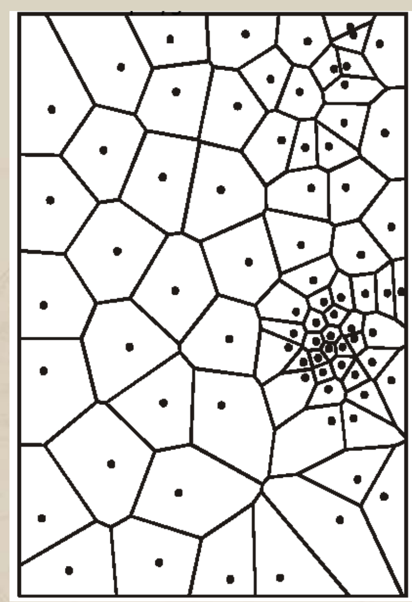








Sampled locations and values



Thiessen polygons

Natural neighbor interpolation

- Based on Thiessen Polygon Network

INTERPOLATION
Fixed-Radius – Local Averaging

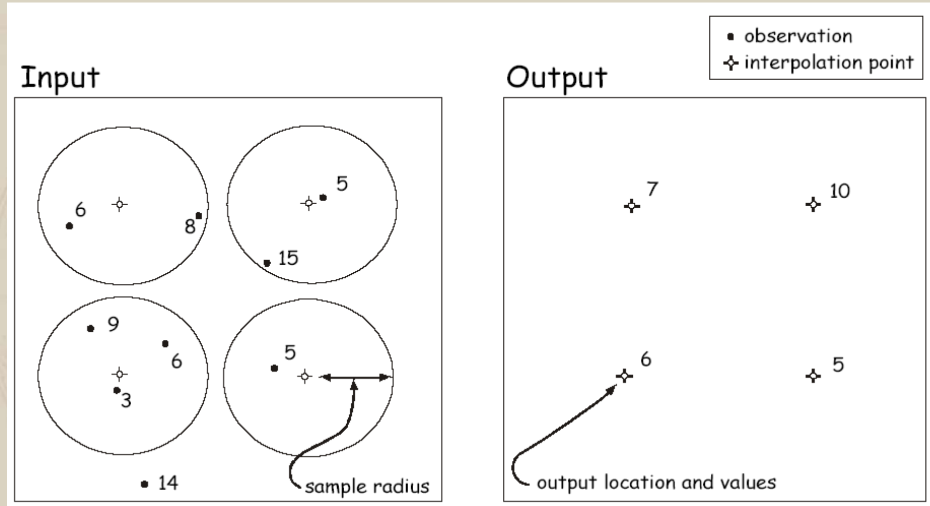
More complex than nearest sample
Cell values estimated based on the average of nearby samples
Samples used depend on search radius
(any sample found inside the circle is used in average, outside ignored)

•Specify output raster grid
•Fixed-radius circle is centered over a raster cell

Circle radius typically equals several raster cell widths
(causes neighboring cell values to be similar)
Several sample points used
Some circles many contain no points
Search radius important; too large may smooth the data too much

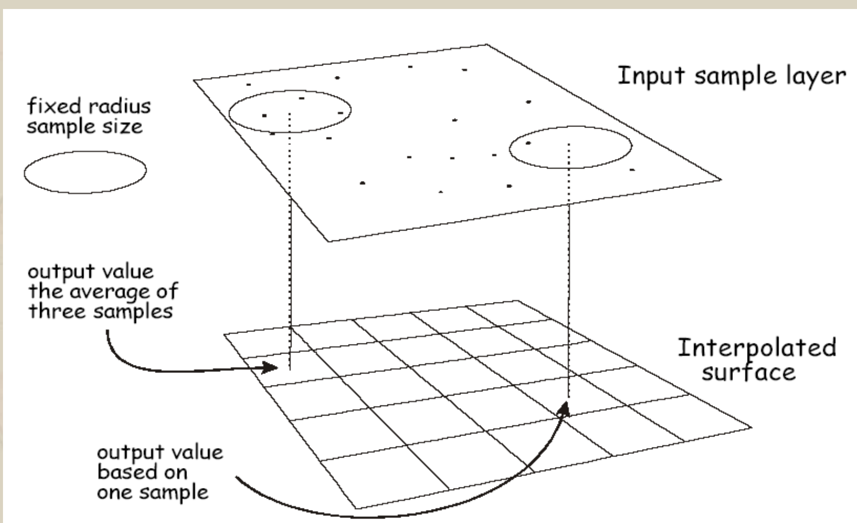
INTERPOLATION

Fixed-Radius – Local Averaging



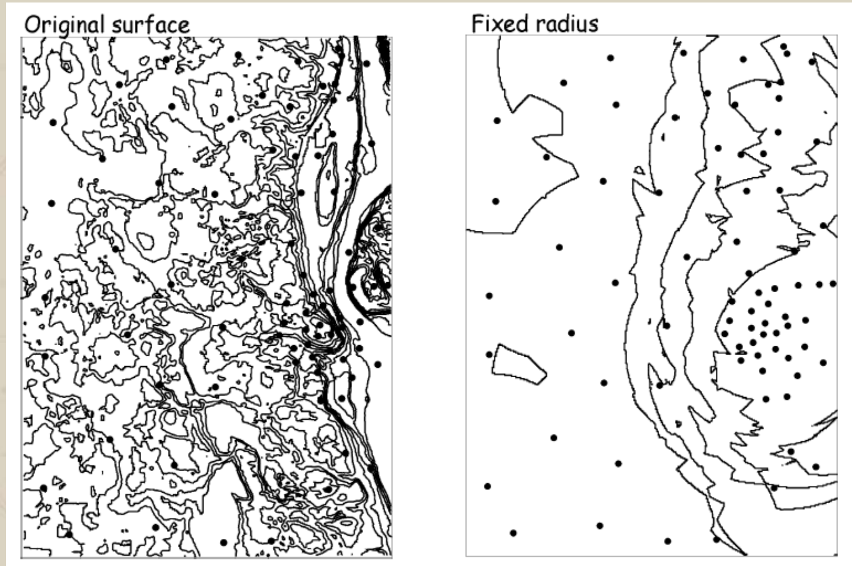
INTERPOLATION

Fixed-Radius – Local Averaging



INTERPOLATION

Fixed-Radius – Local Averaging



INTERPOLATION

Inverse Distance Weighted (IDW)

Estimates the values at unknown points using the distance and values to nearby know points *(IDW reduces the contribution of a known point to the interpolated value)*

Weight of each sample point is an inverse proportion to the distance.

The further away the point, the less the weight in helping define the unsampled location

INTERPOLATION
Inverse Distance Weighted (IDW)

Z_i is value of known point

D_{ij} is distance to known point

Z_j is the unknown point

n is a user selected exponent

$$Z_j = \frac{\sum_i \frac{Z_i}{d^n_{ij}}}{\sum_i \frac{1}{d^n_{ij}}}$$

INTERPOLATION
Inverse Distance Weighted (IDW)

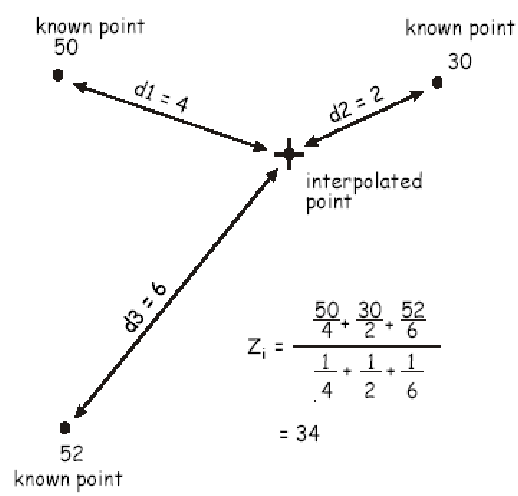


Figure 9-7: An example calculation for a linear inverse distance weighted interpolator. Known points are weighted by the inverse of their distance from the interpolation point, and summed. The sum is then divided by the

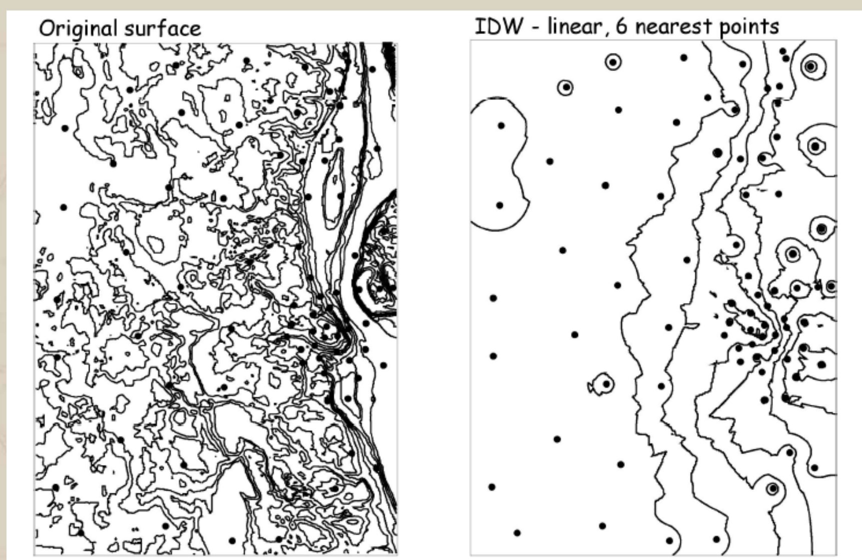
INTERPOLATION
Inverse Distance Weighted (IDW)

Factors affecting interpolated surface:

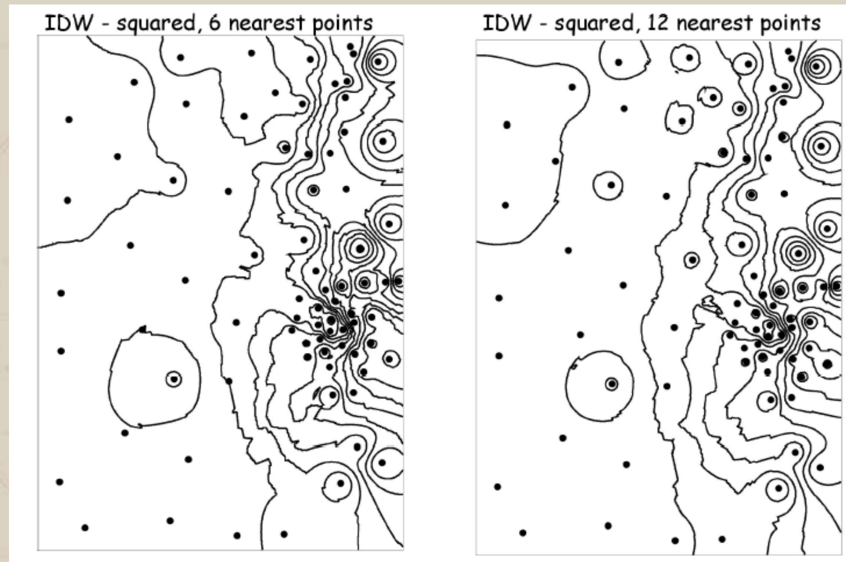
•Size of exponent, n affects the shape of the surface
larger n means the closer points are more influential

•A larger number of sample points results in a smoother surface

INTERPOLATION
Inverse Distance Weighted (IDW)



INTERPOLATION
Inverse Distance Weighted (IDW)



INTERPOLATION
Trend Surface Interpolation

Fitting a statistical model, a trend surface, through the measured points. *(typically polynomial)*

$$Z = a_0 + a_1x + a_2y + a_3x^2 + a_4y^2 + a_5\,xy$$

Where Z is the value at any point x
Where a_is are coefficients estimated in a regression model

INTERPOLATION

Trend Surface Interpolation

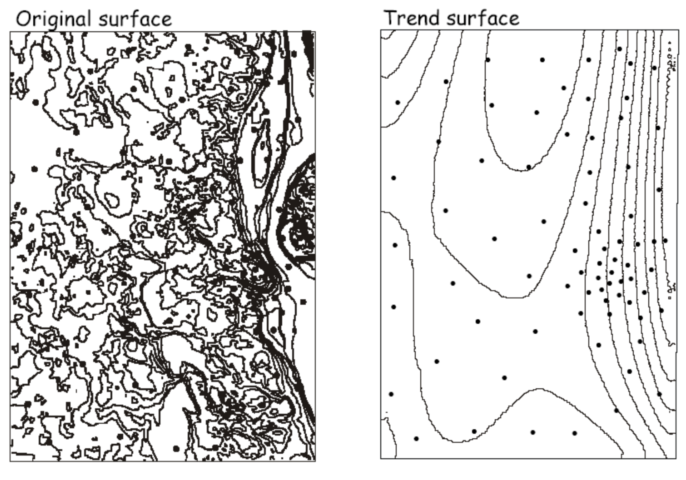


Figure 9-9: Sample points and contours from the original surface (left), and sample points and derived contours from a third order trend surface fit to the sample points (right).

INTERPOLATION

Splines

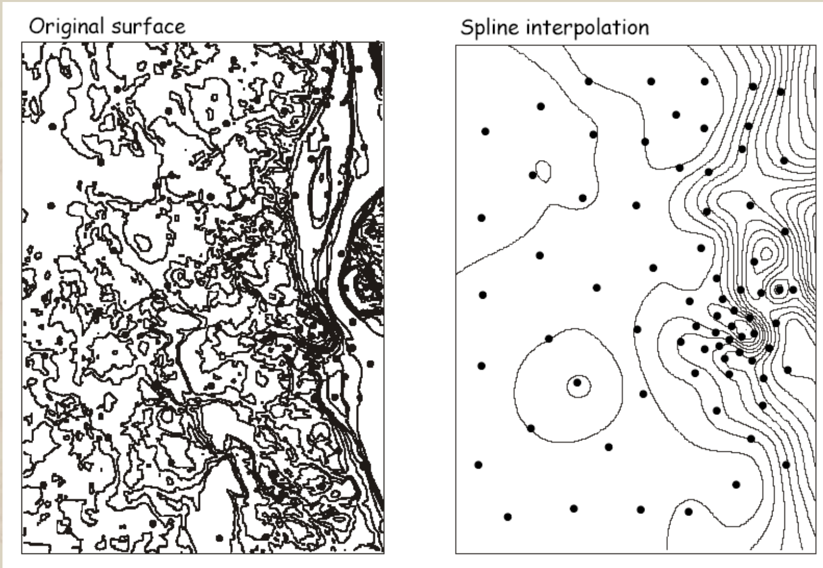
Name derived from the drafting tool, a flexible ruler, that helps create smooth curves through several points

Spline functions are use to interpolate along a smooth curve.

Force a smooth line to pass through a desired set of points

Constructed from a set of joined polynomial functions

INTERPOLATION : Splines



INTERPOLATION
Kriging

Similar to Inverse Distance Weighting (IDW)

Kriging uses the minimum variance method to calculate the weights rather than applying an arbitrary or less precise weighting scheme

Interpolation
Kriging

Method relies on spatial autocorrelation

Higher autocorrelations, points near each other are alike.

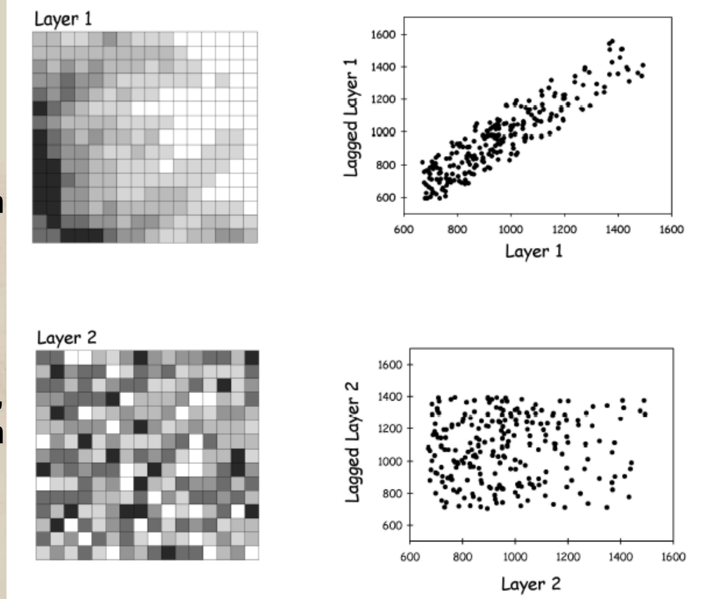


Figure 9-13: Spatially autocorrelated (top) and spatially uncorrelated (bottom) data layers. Plots of nearby sample pairs (right panels) show similar values for autocorrelated Layer 1, and un-related values for uncorrelated layer 2.

INTERPOLATION (cont.)

Exact/Non Exact methods

Exact – predicted values equal observed
Theissen
IDW
Spline

Non Exact-predicted values might not equal observed
Fixed-Radius
Trend surface

Interpolation in ArcGIS: Spatial Analyst