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UNDERSTANDING COMPUTER CONTOURING

"Explorationists conceive mineral deposits and contours in their minds and draw them with a hand guided by experience, data and aesthetics. Someday, computers will be programmed to do as well."

by Stephen A. Krajewski, 1984

COMPUTER & HAND CONTOURING

Computer Contouring

Contour maps are constructed to spatially visualize data, to illustrate a surface, and to express geologic ideas or concepts.

Computer contouring steps include:

1. Prepare data. Scattered data are collected and entered into a database; a base map is plotted; and edits are made.
2. Interpolate values. If triangulating, select triangulation method set up controls, and interpolate values. If gridding, select gridding algorithm; algorithm controls; grid/cell size and orientation; search area size, shape, and orientation; and number and location of scattered data points to be used. Values are then interpolated.
3. Construct and smooth contours.
4. Edit contours by changing interpolation method and/or controls and recontouring, editing grid node values and recontouring, or converting the graphic file to CAD format and interactively edit contour lines.
5. Annotate and reproduce map.

Estimation Methods

Contour lines can be estimated by:

1. Interpolating contour line locations in areas between existing scattered data points.
2. Extrapolating contour line locations in areas beyond existing scattered data points.

Interpolated and extrapolated values can be calculated using two mathematical methods:

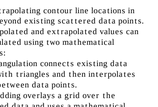
1. Triangulation connects existing data points with triangles and then interpolates values between data points.
2. Gridding overlays a grid over the scattered data and uses a mathematical equation to calculate values at grid cell centers. Gridding algorithms allow both interpolation and extrapolation.

Triangulation is a direct estimation method because the contours are derived directly from the scattered data point values.

Gridding is an indirect estimation method since contours are constructed from the gridded data.

Comparison of Estimation Methods:

The following diagram compares the results of estimating a surface to the same data using different mathematical algorithms.



The following table summarizes common criteria for comparing computer estimated results.

COMPARISON OF COMPUTER CONTOURING METHODS

METHOD	HONOR DATA	SMOOTH CURVES	FAST SPEED	OVERALL ACCURACY
TRIANGULATION	1	5	1	5
INVERSE DISTANCE	3	4	2	4
KRIGING	2	3	5	1
MINIMUM CURVATURE	4	2	4	3
TREND SURFACE	5	1	3	2

1 = BEST ... 5 = WORST

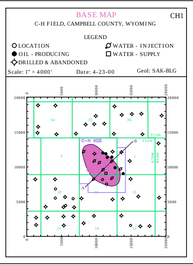
The Carson-Hamm Oil Field

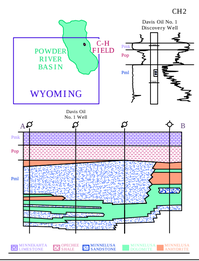
The Carson-Hamm (C-H) Oil Field is located on the eastern flank of the Powder River Basin in northeastern Wyoming, USA.

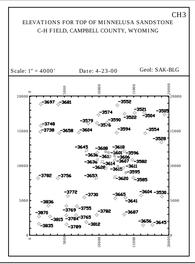
The C-H Field was discovered when the Davis Oil #1 well was completed on January 30, 1967 at a depth of 7,681 feet. Fifty-eight additional wells have been drilled: 44 dry holes, 6 producers, and 9 water wells.

The distance between wells varies between 175 and 6,000 feet with the average distance being 2,135 feet. Kelly bushing elevation and formation top and thickness data were obtained from sonic and density logs which were available for all drillholes.

The C-H Field is approximately 8,000 feet long and 4,000 feet wide. The pay sand varies from 0 to 51 feet thick with average pay zone thickness being 21 feet. The long axis of the C-H Field trends northwest to southeast; and, regional dip is about 3-5 ° to the southwest. Faults are not present in the area.







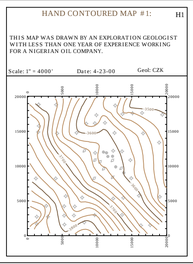
Hand Contouring

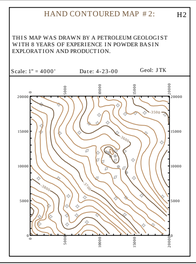
The oldest hand contoured map was drawn by Pieter Bruinss in 1584. The map shows depth contours in a section of the River Spaarne in Holland.

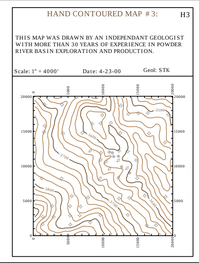
Hand contouring methods include: mechanical, parallel, equal spaced and interpretive.

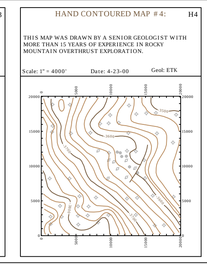
Rules covering hand drawing of contours include: contour lines cannot cross or merge, and must close; contour lines are repeated at slope changes; contours are separated by a constant vertical interval and the interval should be small enough to see important features; contour lines should be drawn smooth and not undulating (contour wiggles have meaning); contours are drawn based on experience, data and aesthetics.

When no data or concept is available, contours should be drawn parallel and as equal spaced as possible. Contours drawn by hand can be easily changed with a pencil and eraser. Computer contours are changed by varying setups in the calculation protocol.









GRID SIZE
SIZE
SHAPE
ORIENTATION

Terminology

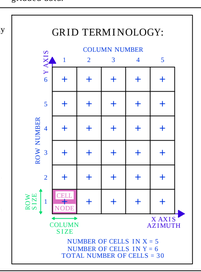
Grid meshes are rectagular arrays of regularly spaced points that are superimposed over scattered data points. A grid cell is one unit area within a grid mesh; and, a grid node is the point at the cell center.

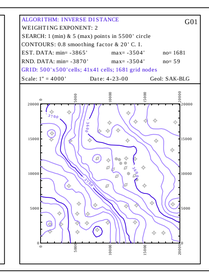
Grid setup parameters include:

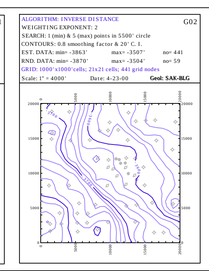
- Area to be covered
- Origin coordinate in X and Y
- Cell size
- Cell shape
- Number of cells in X and Y
- Cell node location
- Baseline azimuth of grid's X axis

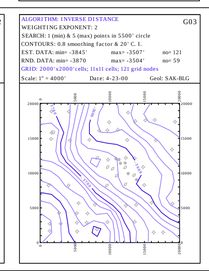
Grids should be rotated so that more grid nodes occur within target geometry, or to more closely align line-oriented data with grid node locations.

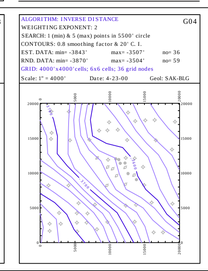
Grids should be large enough to cover an area including the target geometry plus a buffer of 15-20% on all sides of the target. Cells should be sized such that 2-3 cells occur between average data spacing. Grid origins are usually in the southwest corner of the grid.

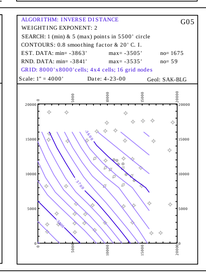


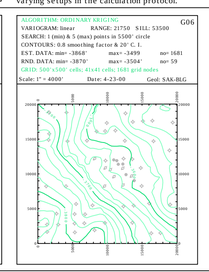


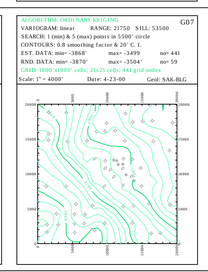


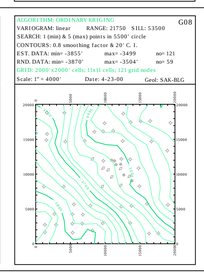


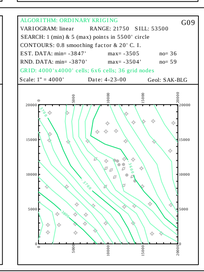


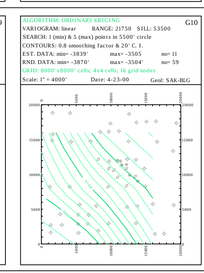












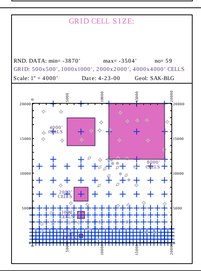
Grid Cell Size Maps

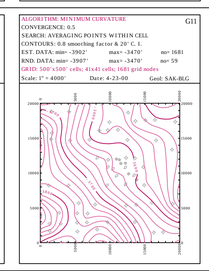
Maps G01-20 show the results of varying grid cell size from 500x500', 1000x1000', 2000x2000', 4000x4000' to 8000x8000'; and, using different algorithms: inverse distance (G01-05), ordinary kriging (G06-10), minimum curvature (G11-15) and trend surface (G16-20) algorithms).

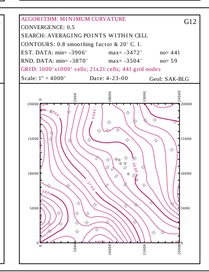
Grid size should be controlled by data spacing and distribution, variability in the surface being estimated, and by target geometry.

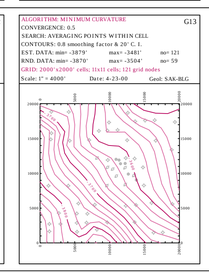
Small cell size is used with closely spaced data, a highly variable geologic surface (channel sand), and a small target. Large cell size is used with widely spaced data and a non-varying geologic surface (top of a coal seam existing over hundreds of square miles).

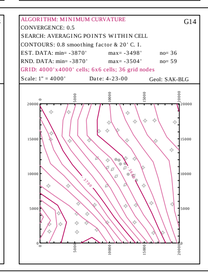
Grid cell size must be small enough to have nodes within the target. When cell size equals or is greater than target size, it becomes impossible to estimate target presence, i.e., small target geometries cannot be seen.

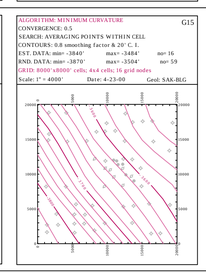


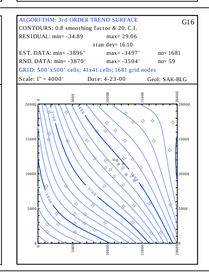


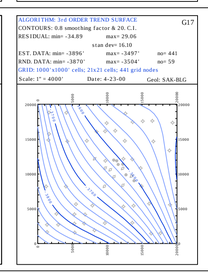


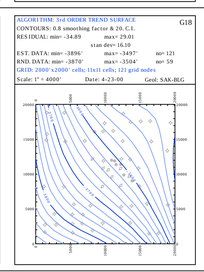


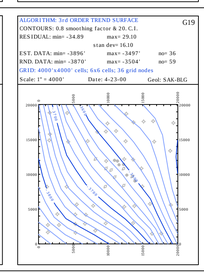


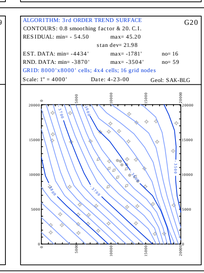












SEARCH AREA
SIZE
SHAPE
ORIENTATION
WEIGHTING

Terminology

The search area is the neighborhood from which scattered data points will be used by an algorithm to estimate grid node values.

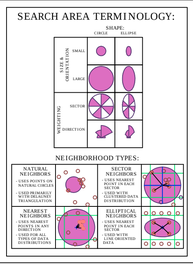
Search area parameters include:

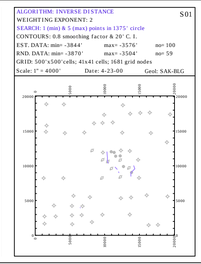
- Size: small or large
- Shape: circle or ellipse
- Orientation of ellipse
- Weighting: more or less weight is given depending on direction and/or distance

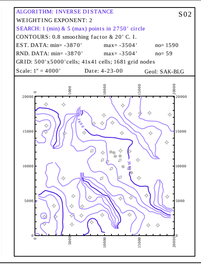
Search area size should be large enough to include an optimal number of data points:

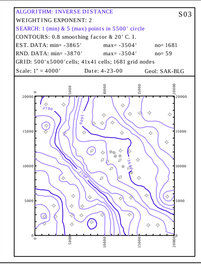
- If area is too small, no data are available. Calculation time is fast and "local anomalies" are enhanced.
- If area is too large, lots of data are available. Calculation time is longer and "local anomalies" will be smoothed.
- If area is very large, all data can be used to estimate every node. This would result in a moving average calculation.

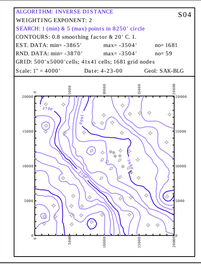
The goal should be to use data evenly distributed around grid nodes.

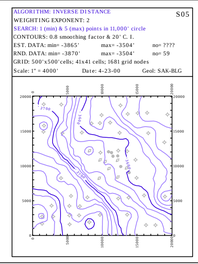


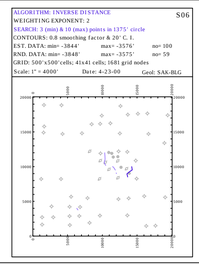


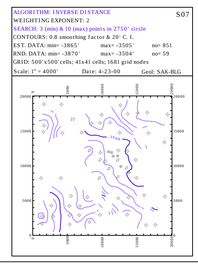


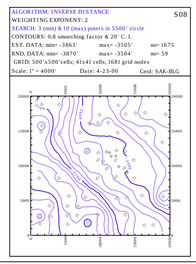


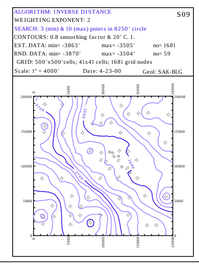












Search Area Size

Maps S01-20 show the results of using five different circular search areas (1375', 2250', 5500', 8250' and 11,000') with two different algorithms (inverse disrtance (S01-10) and kriging (S011-20)). Additional maps could also be made using an elliptical search.

Map S01-02 and s11-12 show the effects caused by using too small a search area. Areas of the maps have no contours at all, indicating that those cells did not have scattered data points within the search area that could be used to give an estimated value to the cells. This also causes the contours to "pinch" or become a contouring artifact.

Other map examples show little difference between a smaller and larger search radius, so making the search radius larger is not significant. The minimum and maximum estimated values change.

Notice the "bullet hole" and "step" artifacts which are common when using the inverse distance algorithm.

NUMBER OF DATA POINTS
NUMBER
PATTERN
ORIENTATION

Terminology

The number of scattered data points used