Surface modeling

A representation of a geographic feature or phenomenon that can be measured continuously across some part of the earth's surface (for example, elevation). A surface model is an approximation of a surface, generalized from sample data. Surface models are stored and displayed as rasters, TINs, or terrains.

The **Surface Modeling** process allows you to construct and transform representations of natural terrains and mathematical surfaces from the 3D information you provide. The Surface Fitting, Contouring, and Triangulation operations allow you to produce Digital Elevation Model rasters (DEMs), contour lines, and triangulated irregular networks (TINs), respectively.

Gridding (Modeling) Technique

What is a Grid?

A surface model (or grid) is a set of points that are regularly distributed estimates of some attribute over an area (Figure-1). Grids are usually generated from a control point dataset. Control points are a set of points that are randomly distributed and are samples of some attributes over and area (Figure-1).

Figure-1 Grid with control points data. (ZmapPlus Mapping (2002), Subsurface Mapping and Non-Default Griding Techniques. Landmark- Houston USA.)

Grid is generated on any Z-values that are represented on the Z-axis in 3D dimensional X, Y, and Z coordinate system. Some examples of control point data sets include: well top picks and other borehole-related data, 2D and 3D seismic data, gravity and magnetic survey, existing contour map and temperature & pressure.

The purpose of Gridding

Grids are produced in order to achieve an even distribution of points. Some examples of functionality that depend on the even distribution of points includes: generating contours on a map, producing perspective (3D) display, drawing grid profiles (cross section), performing grid operation, volumetric calculations, and back interpolation-the ability to query the grid at any location to determine a reasonable value.

Grid Terminology

The following is a list of terms commonly associated with grids: Grid nodes individual estimated values that cumulatively make up the entire grid. Grid columns and rows – grid nodes are arranged in columns and rows, and a specific grid node can be uniquely identified by the column and row it resides in. Grid cells – the region bounded by four grid nodes. Many computer functions are performed on a cell-by- cell basis. Grid increment – the spacing between columns (x-inc) and rows (y-inc) of grid nodes. The grid increment is a parameter that you can set that determines the size of features that can be retained by grid node spacing (Figure-2).

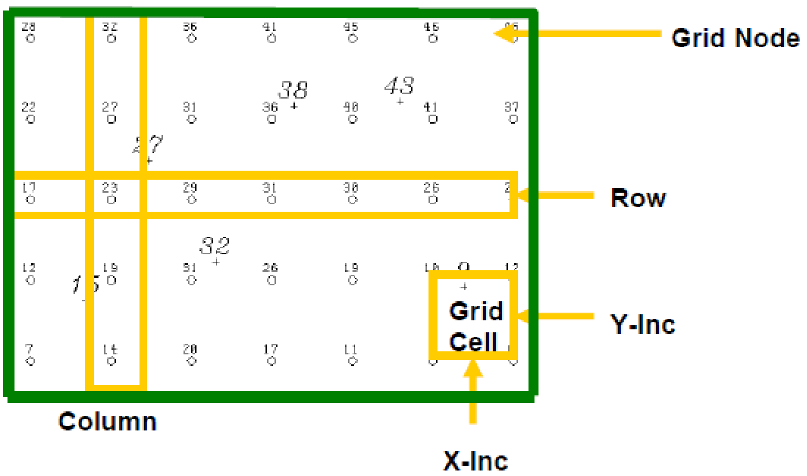

Figure-2 Grid Terminology; ZmapPlus Mapping (2002), Subsurface Mapping and Non-Default Griding Techniques. Landmark- Houston USA.

Models Structures with GIS

The ideal structure for a digital elevation model (DEM) depends on the intended use of the data and how it might relate to the structure of the model. Figure 4 illustrates the three principal ways of structuring a DEM Raster, TIN, and vector models.

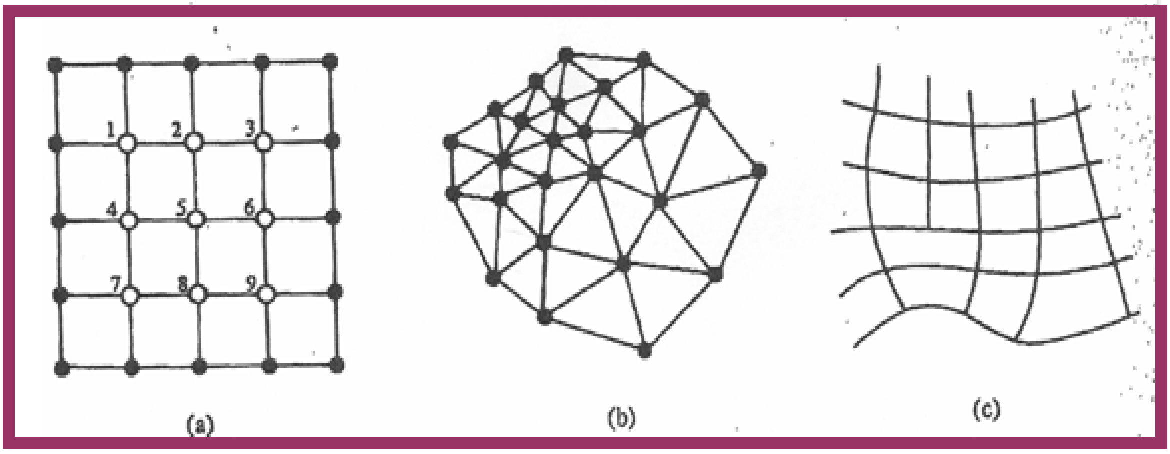

Figure-4 Method of structuring an elevation data network: (a) Raster grid. (b) TIN model. (c) Vector model. (Ian D. Moore, GIS and Land-surface process modeling).

Raster Model

Raster surfaces are usually in grid format that consist of a rectangular array of uniformly spaced cells with Z-values (figure 5). Grid cell values are calculated from amathematical function relating nearby control points. Usually this function is a form of a spatial average, where the closer control points are weighted more heavily than the more distance once**.**

Variants of this function include fitting a plane or curved surface to the control data in order to estimate grid cell values by mean of regression or projection. Contours are then generated based on the regularly spaced grid values. The data can be stored in a variety of ways, but the most efficient is as Z coordinates corresponding to sequential points along a profile with the starting point and grid spacing also specified.

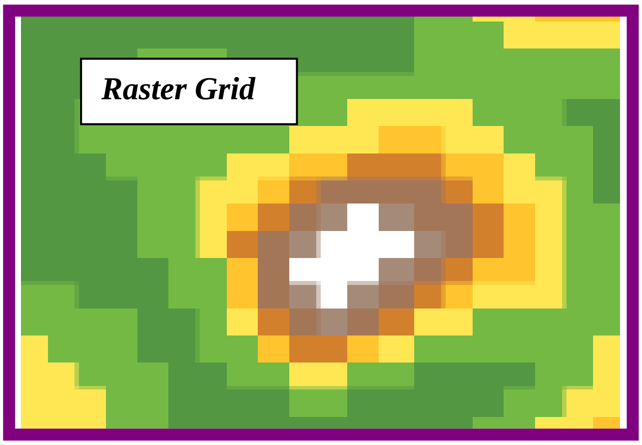

Figure 5 Raster Model (ArcGIS- ESRI, Creating surface models)

The most widely used data structures consist of square grid networks because of their ease of computer implementation and computational efficiency. However, they do have several disadvantages. They cannot easily handle abrupt change in elevation. The size of grid mesh affects the result obtained and the computational efficiency. The computed upslope flow paths used in hydrological analysis tend to zigzag and therefore are somewhat unrealistic. Also another disadvantage with grid-based contours is that control point data may not exactly fit the contours, because the contours are based on calculated cell values.

The advantages of grid interpolation are that complex surface model algorithms are better suited for a continuous array of evenly spaced data rather than an irregular spatial distribution. (ArcGIS9-Creating Surface Models). Two-grid interpolation Functions, spline and inverse distance weighted (IDW), are available in pull down menus with in 3D Analyst and Spatial Analyst. The Spatial Analyst provides much more user control and spatial analysis tools than the 3D analyst. Additional interpolators available through both of these ArcView GIS extensions include kriging and trend.

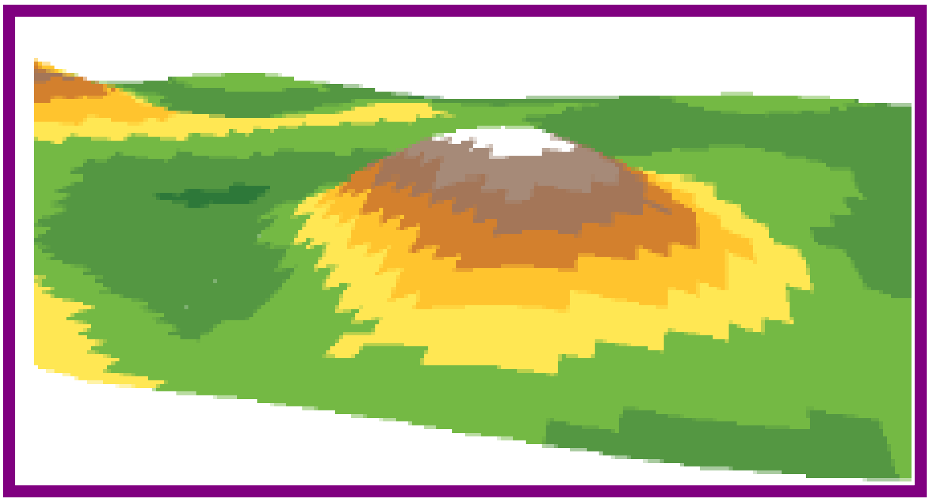

Figure-6 Raster Grid in perspective view (ArcGIS, ESRI, Creating surface models)

TIN Model

The Triangulated Irregular Network (TIN) is a surface representation based on randomly or irregularly spaced data points that have x,y, and z coordinates. A typical example of this coordinate system is longitude (x), and latitude (y), and an elevation or concentration (Z). Non-overlapping, connecting triangles are drawn between all data points where the data points (or control points) are the vertices (Figure 7)

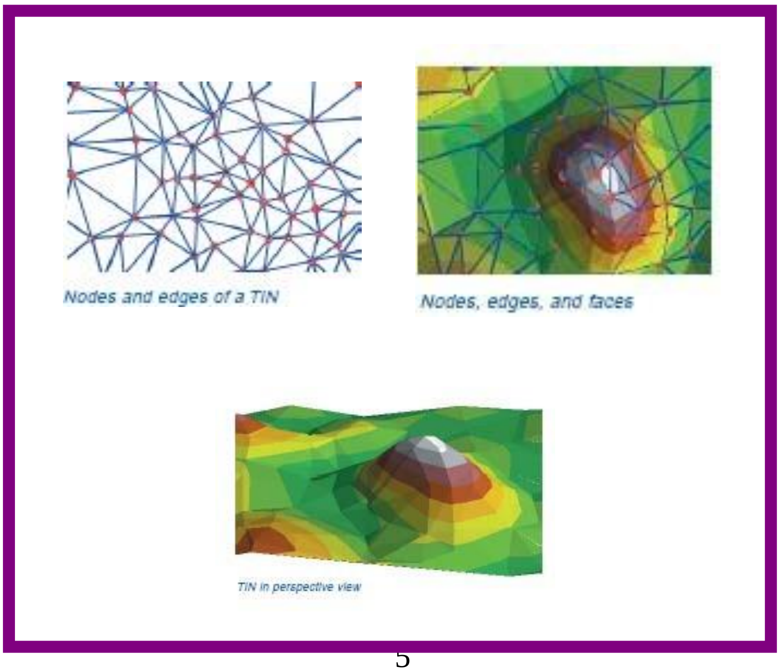

Figure 7 TIN models. (ArcGIS- ESRI, Creating surface models)

In its basic form, TIN elevations are calculated based on linear regression between control points; contours are then drawn across the sides of the connected, tilting triangular plates (figure 7).

The wide distribution of control- point data yields a coarse, angular surface representation that is not desirable for structure contour and isopack maps; the angularcontours do not accurately reflect the natural geologic environment.

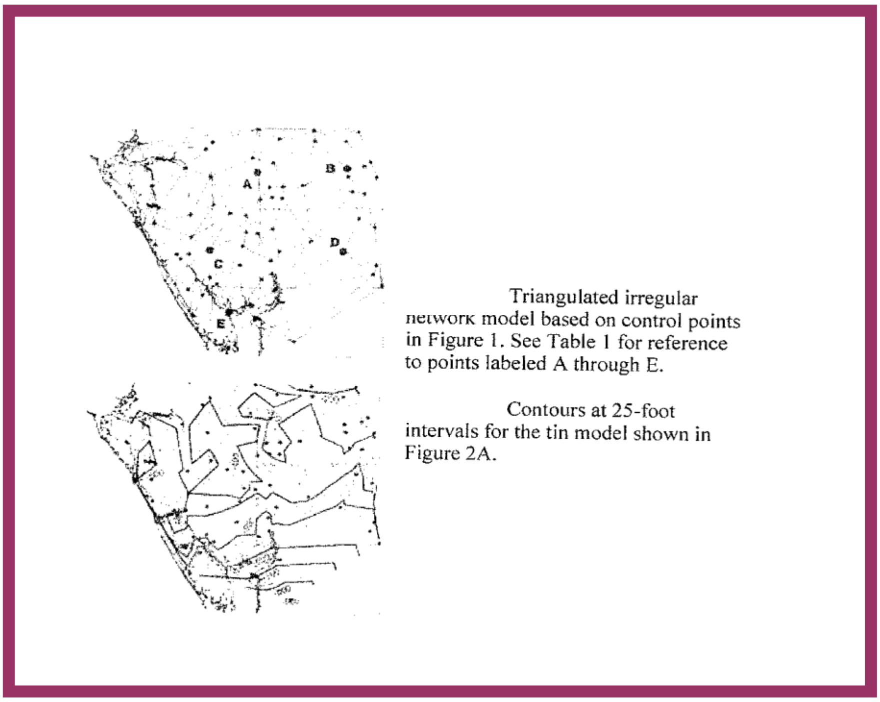

Figure 8 TIN model based on control points. (Jonathan D. Arthur, use of ArcGIS for geologic surface modeling.)

Figure 8 shows a TIN surface model representing the top surface using the control points. The 3D analyst was used to create a model which is contoured at 25-foot intervals. The wide distribution of control-point data yields a coarse, angular surface representation that is not desirable for structure contour and isopach maps; the angular contours do not accurately reflect the natural geologic environment. Two advantages with tin, however, are that it does not interpolate beyond the distribution of the data, and the map is forced to fit the control points. TIN is well suited for the purpose of generating a more highly resolved structure on which to drape or hang feature layers.

Vector Model

Vector or contour – based methods consists of digitized contour lines and are stored as digital line graphs (DLGs) in the form of x, y coordinate pairs along each contour line of specified elevation. These can be used to subdivide an area into irregular polygons bounded by adjacent contour lines and adjacent streamlines. Contour – based methods of partitioning catchments (Figure-4) and terrain analysis provide a natural way of structuring hydrological and water quality models because the partitioning is based on the hydraulics of fluid flow in the landscape.

Vector analysis is better where are definable regions and relative position of the objects. Also vector is better in modeling routes and networks. They are specifically used in all legal, administrative boundaries, roads, pipelines, power lines, flight paths and transportation routes.

Surface Modeling Highlights

- Construct a DEM from contour lines, a TIN, point data, or database records containing 3D coordinates.
- Assign elevations for the DEM by query from any numeric database field associated with the input data
- Efficiently process datasets with thousands of points or contour lines to produce large, detailed DEMs
- Geospatial scripting language (SML) can read, modify, and create geospatial data and attribute information for raster, vector, CAD, shape, and TIN
- Choose from many interpolation methods for surface fitting such as Minimum Curvature, Inverse Distance, Profiles, and Polynomial
- Use geostatistics to fit a surface to your point data via the Kriging method

- Choose the cell size and numeric type for the DEM
- Create contour lines from a DEM or TIN using Linear or Iterative Thresholding methods
- Fast, efficient contouring of even very large DEMs
- Produce smoother contour lines using optional smoothing and resampling of the DEM
- Create a TIN from a DEM, contour lines, or point data
- Use breaklines to create "hard" TIN edges that are preserved in the event of further changes in the TIN structure
- Use polygon breaklines to limit the extents of the TIN
- Use optimization settings to constrain the density and detail of the TIN
- Bidirectional surface fitting specially tailored for geophysical data acquired along parallel transect lines