Chapter 13. TERRAIN MAPPING AND ANALYSIS

Data for Terrain Mapping and Analysis

- DEM (digital elevation model) and TIN (triangulated irregular network) are two common types of input data for terrain mapping and analysis.
- A DEM represents a regular array of elevation points. It can be converted to an elevation raster by placing each elevation point at the center of a cell.
- A TIN approximates the land surface with a series of nonoverlapping triangles.
- A DEM can be converted into a TIN by using the maximum *z*-tolerance algorithm or the VIP (very important point) algorithm.
- A TIN can be converted into a DEM by using local first-order polynomial interpolation.

Input Data to TIN

Besides DEM, a TIN can also use additional point data such as surveyed elevation points, GPS (global positioning system) data, and LIDAR data; line data such as contour lines and breaklines; and area data such as lakes and reservoirs.

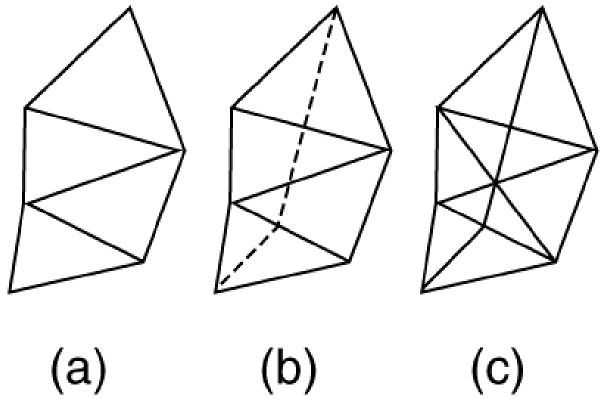

Figure 13.1
A breakline, shown as a dashed line in (b), subdivides the triangles in (a) into a series of smaller triangles in (c).

Terrain Mapping

Terrain mapping techniques include contouring, vertical profiling, hill shading, hypsometric tinting, and perspective view.

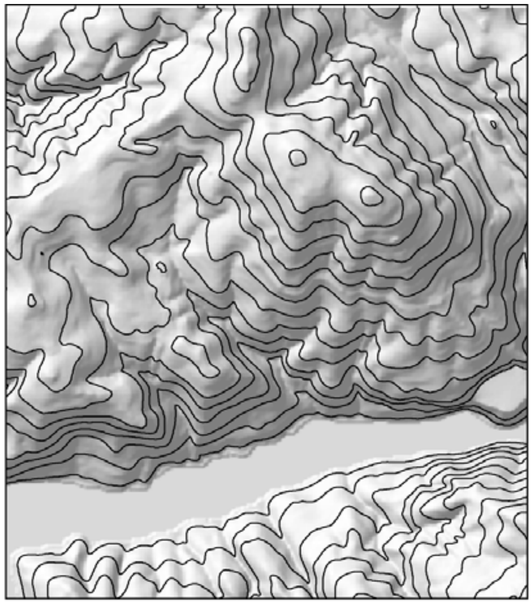

Figure 13.2
A contour line map.

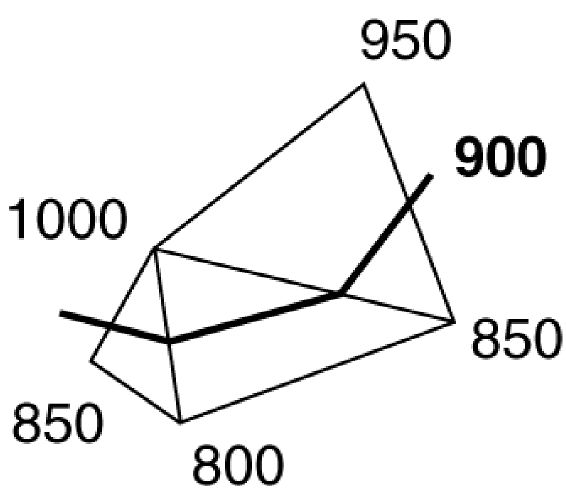

Figure 13.3
The contour line of 900 connects points that are interpolated to have the value of 900 along the triangle edges.

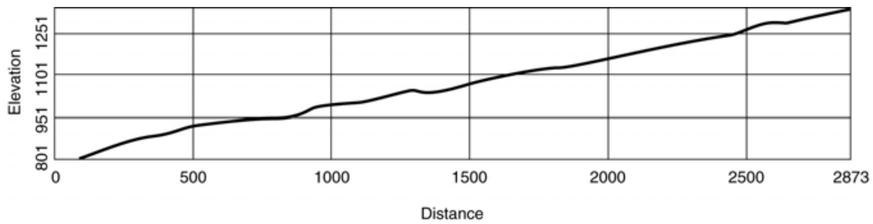

Figure 13.4
A vertical profile.

Figure 13.5
An example of hill shading, with the sun's azimuth at 315° (NW) and the sun's altitude at 45°.

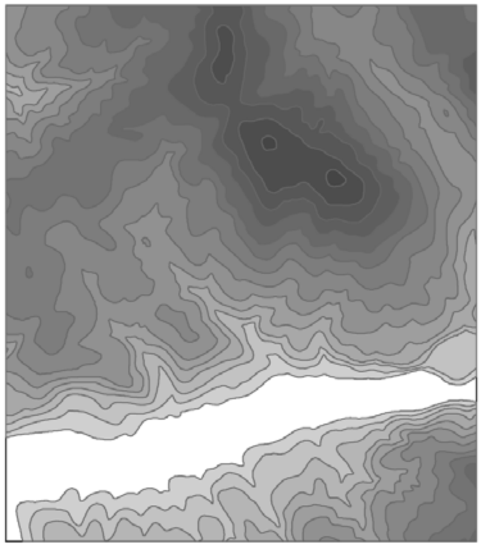

Figure 13.6
A hypsometric map. Different elevation zones are shown in different gray symbols.

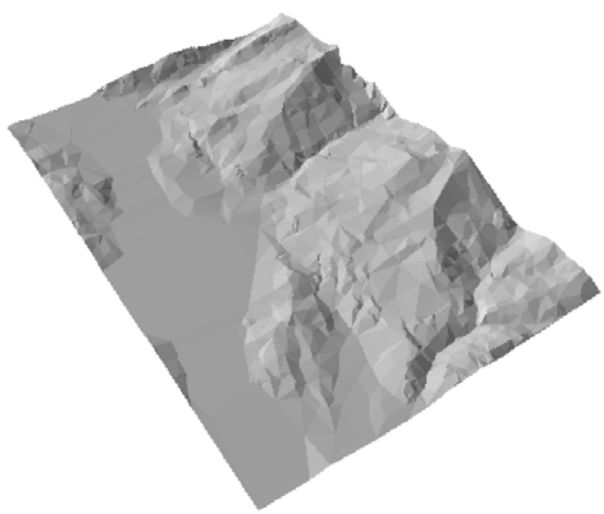

Figure 13.7
A 3-D perspective view.

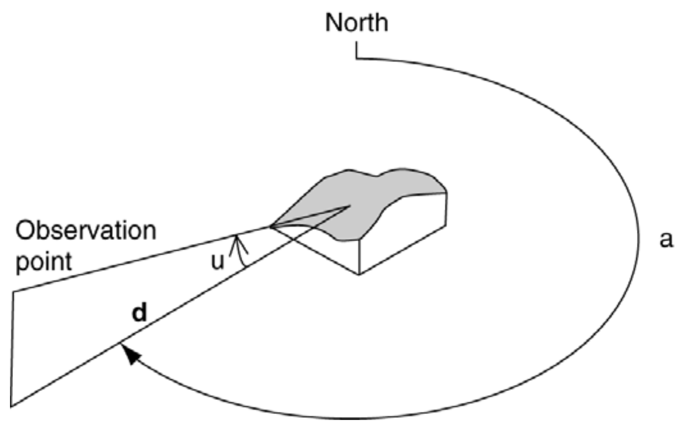

Figure 13.8
Three controlling parameters of the appearance of a 3-D view: the viewing azimuth *a* is measured clockwise from the north, the viewing angle *u* is measured from the horizon, and the viewing distance *d* is measured between the observation point and the 3-D surface.

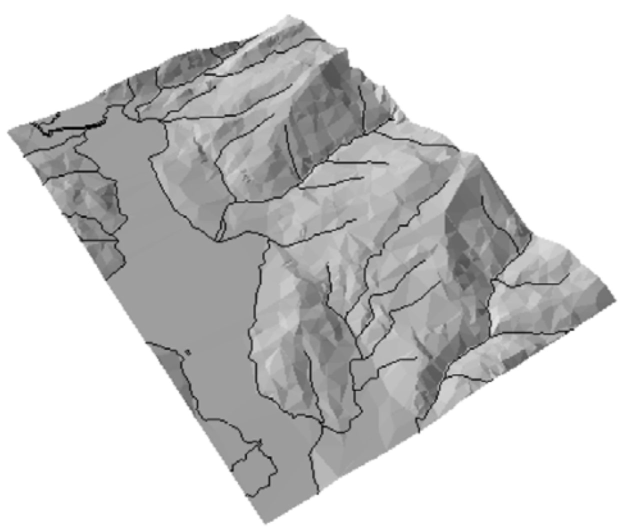

Figure 13.9
Draping of streams and shorelines on a 3-D surface.

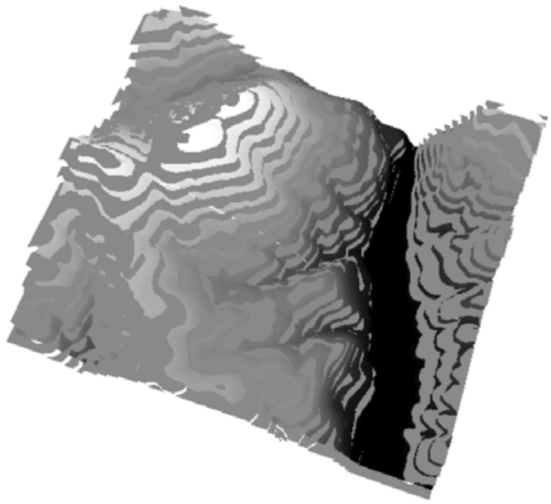

Figure 13.10
A 3-D perspective view of an elevation zone map.

Figure 13.11
A view of 3-D buildings in Boston, Massachusetts.

Slope and Aspect

- Slope measures the rate of change of elevation at a surface location. Slope may be expressed as percent slope or degree slope.
- Aspect is the directional measure of slope. Aspect starts with 0° at the north, moves clockwise, and ends with 360° also at the north. Because it is a circular measure, We often have to manipulate aspect measures before using them in data analysis.

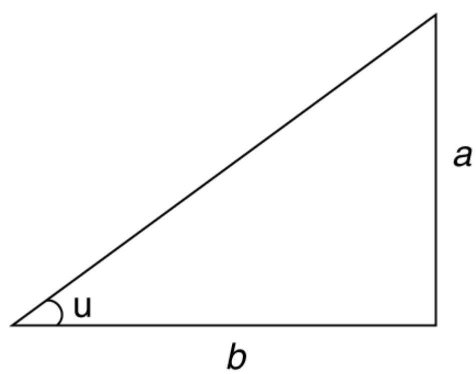

Figure 13.12
Slope, either measured in percent or degrees, can be calculated from the vertical distance *a* and the horizontal distance *b*.

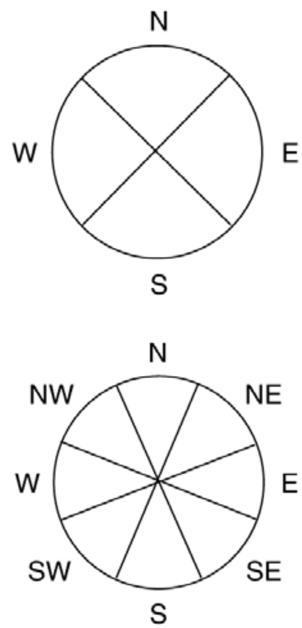

Figure 13.13
Aspect measures are often grouped into the four principal directions (top) or eight principal directions (bottom).

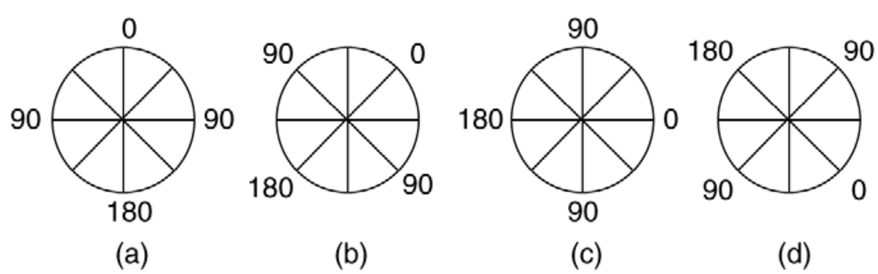

Figure 13.14
Transformation methods to capture the N–S direction (a), the NE–SW direction (b), the E–W direction (c), and the NW–SE direction (d).

Computing Algorithms for Slope and Aspect Using Raster

- The slope and aspect for an area unit (i.e., a cell or triangle) are measured by the quantity and direction of tilt of the unit's normal vector—a directed line perpendicular to the unit.
- Different approximation (finite difference) methods have been proposed for calculating slope and aspect from an elevation raster. Usually based on a 3-by-3 moving window, these methods differ in the number of neighboring cells used in the estimation and the weight applying to each cell.

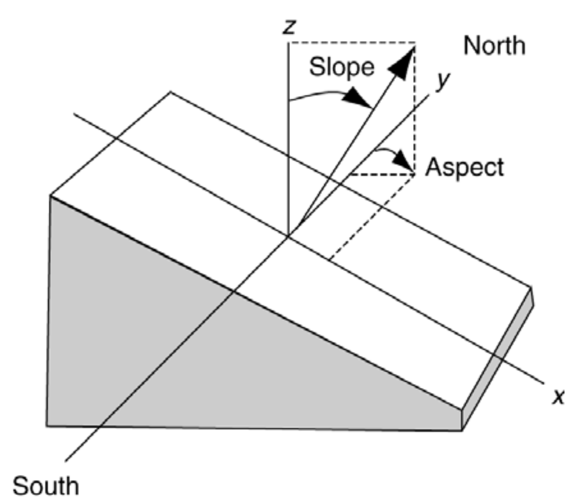

Figure 13.15
The normal vector to the cell is the directed line perpendicular to the cell. The quantity and direction of tilt of the normal vector determine the slope and aspect of the cell.

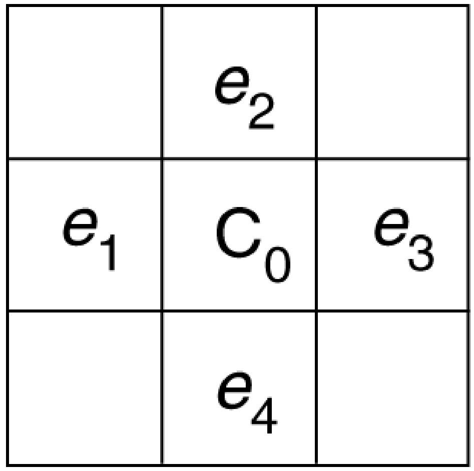

Figure 13.16
Ritter's algorithm for computing slope and aspect at C_0 uses the four immediate neighbors of C_0.

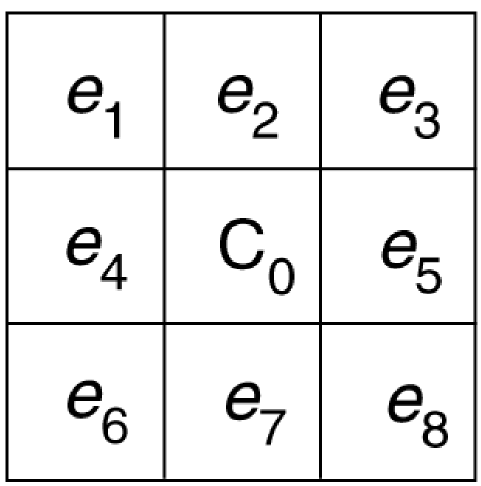

Figure 13.17
Horn's algorithm for computing slope and aspect at C_0 uses the eight neighboring cells of C_0. The algorithm also applies a weight of 2 to e_2, e_4, e_5, and e_7, and a weight of 1 to e_1, e_3, e_6, and e_8.

Computing Algorithms for Slope and Aspect using TIN

The *x*, *y*, and *z* values of points that make up a TIN are used to compute slope and aspect for each triangle.

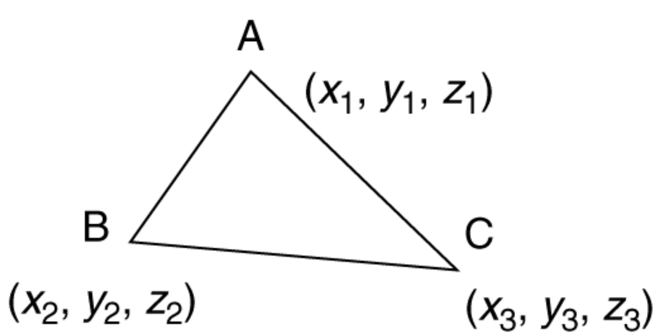

Figure 13.18
The algorithm for computing slope and aspect of a triangle in a TIN uses the *x*, *y*, and *z* values at the three nodes of the triangle.

Factors Influencing Slope and Aspect Measures

Factors that can influence slope and aspect measures include the resolution of DEM, the quality of DEM, the computing algorithm, and local topography.

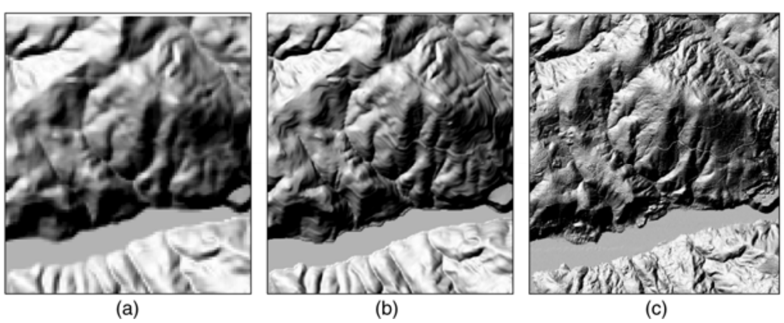

Figure 13.19
DEMs at three different resolutions: USGS 30-meter DEM (a), USGS 10-meter DEM (b), and 1.83-meter DEM derived from LIDAR data (c).

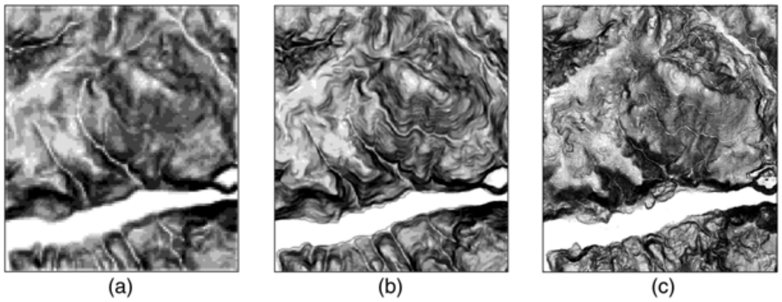

Figure 13.20
Slope layers derived from the three DEMs in Figure 13.19. The darkness of the symbol increases as the slope becomes steeper.

Surface Curvature

Surface curvature measures can determine if the surface at a cell location is upwardly convex or concave.

National Elevation Dataset
http://gisdata.usgs.gov/ned/