Geographic Information Systems 2018/19
Week 10, Topic 2

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In this session...

Terrain Mapping and Analysis

- Data for Terrain Mapping and Analysis
- Terrain Mapping
- Slope and Aspect
- Surface Curvature
- Raster Versus TIN

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.

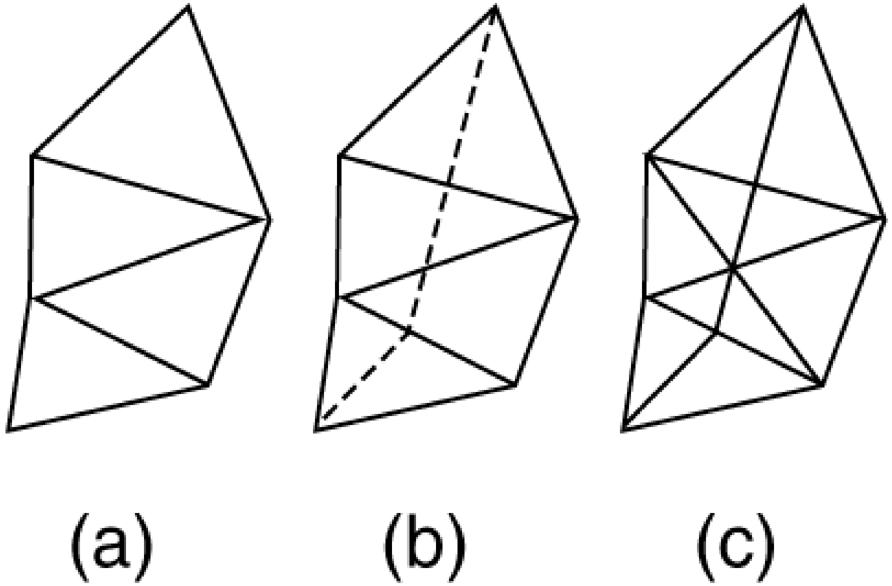
A TIN approximates the land surface with a series of non-overlapping triangles.

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

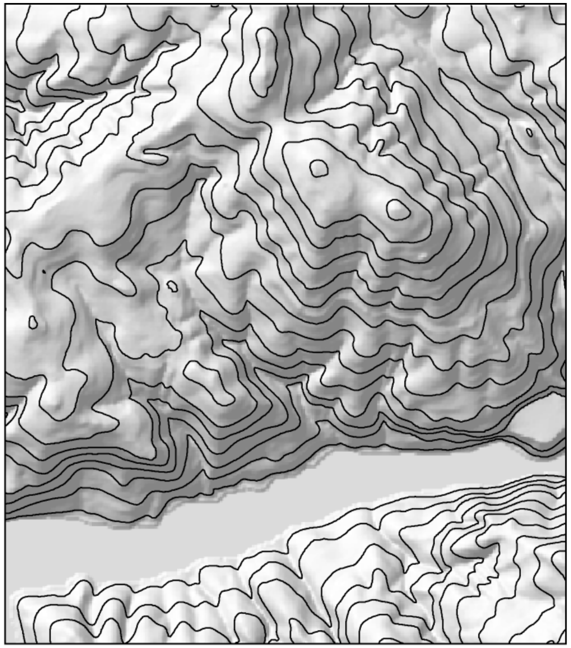
Besides DEM, a TIN can also use additional point data such as surveyed elevation points, GPS (global positioning system) data, and LIDAR data; line data such as contour lines and breaklines; and area data such as lakes and reservoirs.

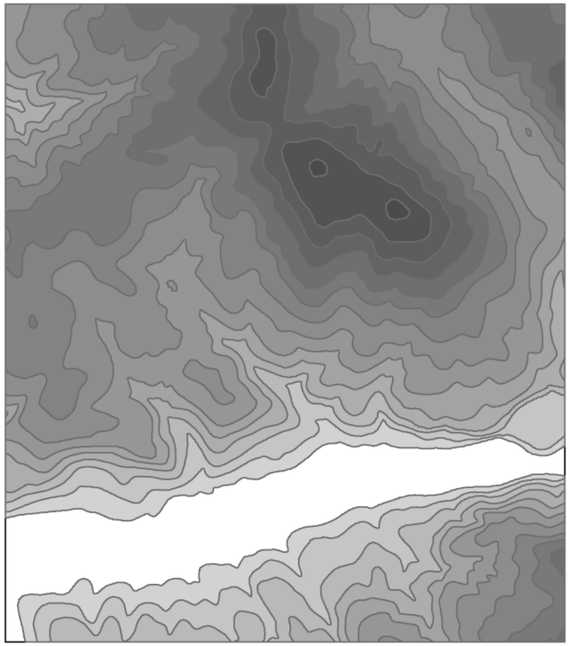


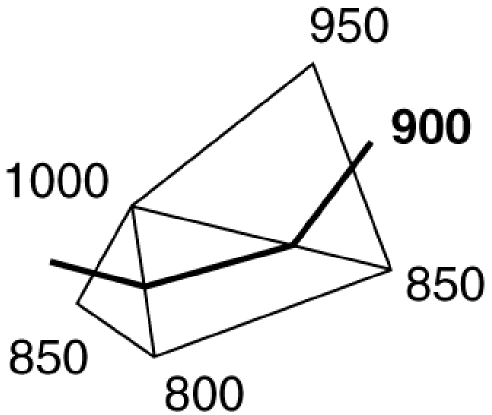
A breakline, shown as a dashed line in (b), subdivides the triangles in (a) into a series of smaller triangles in (c).

Terrain Mapping

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

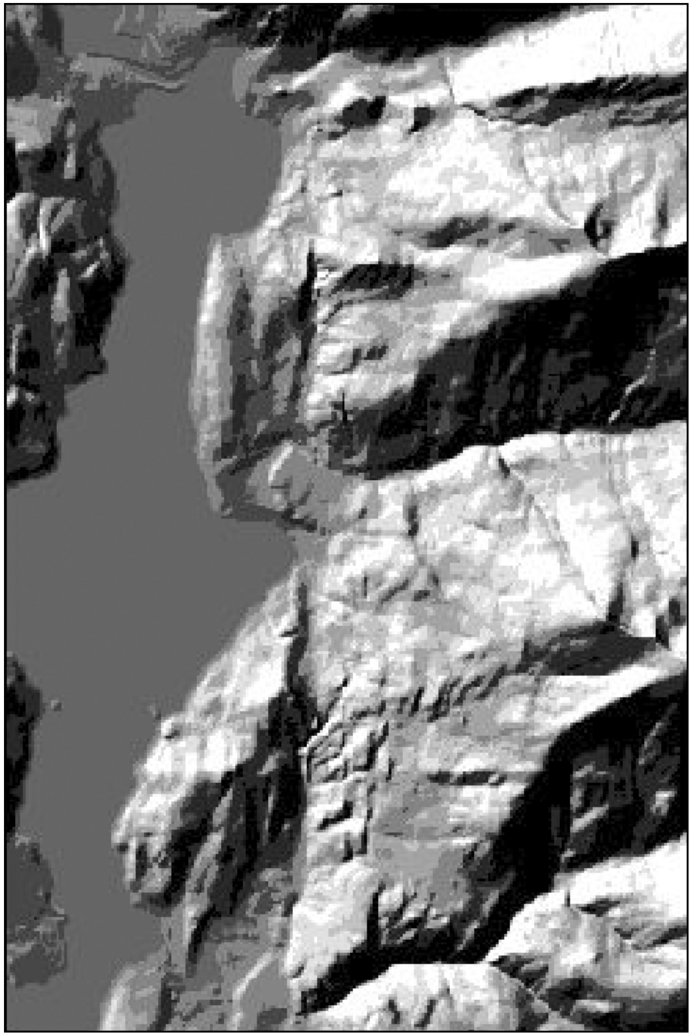






The contour line of 900 connects points that are interpolated to have the value of 900 along the triangle edges.

Hill Shading

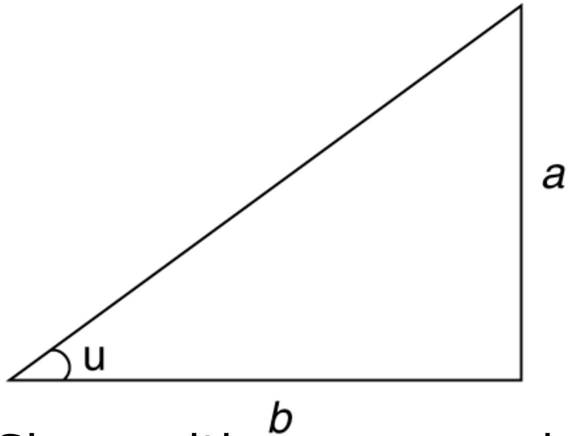


An example of hill shading, with the sun’s azimuth at 315° (NW) and the sun’s altitude at 45°.

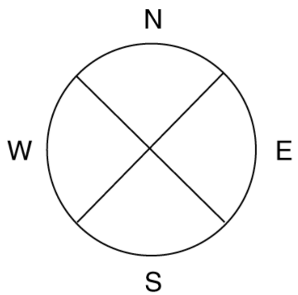
Slope and Aspect

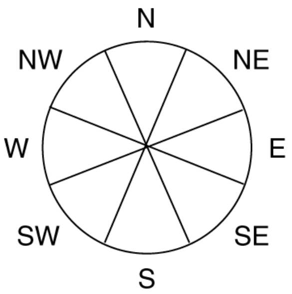
Slope measures the rate of change of elevation at a surface location. Slope may be expressed as percent slope or degree slope.

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.



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



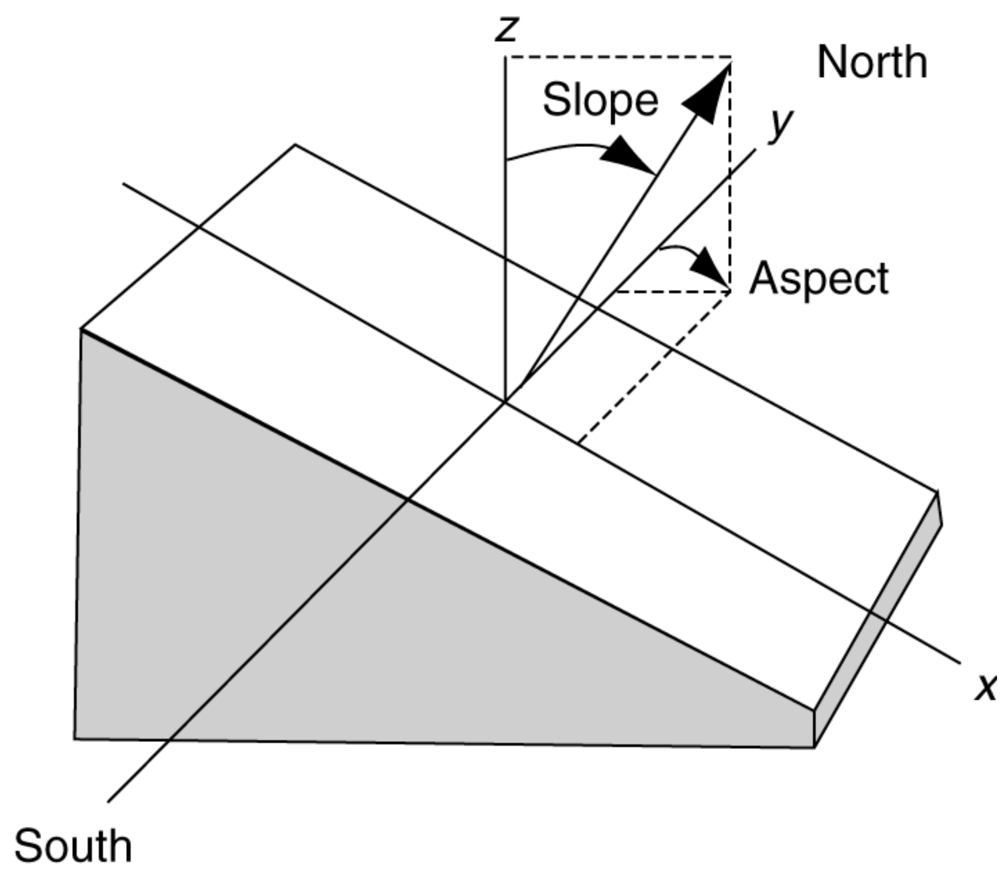


Aspect measures are often grouped into the four principal directions (top) or eight principal directions (bottom).

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.



Slope

50	45	50
30	30	30
8	10	10

The rate of change in the x direction for the centre cell e is:

[dz/dx] = ((c + 2f + i) - (a + 2d + g) / (8 * x_cellsize)

= ((50 + 60 + 10) - (50 + 60 + 8)) / (8 * 5)

= (120 - 118) / 40

= 0.05

The rate of change in the y direction for cell e is:

[dz/dy] = ((g + 2h + i) - (a + 2b + c)) / (8 * y_cellsize)

= ((8 + 20 + 10) - (50 + 90 + 50)) / (8 * 5)

= (38 - 190) / 40

= -3.8

Taking the rate of change in the x and y direction, the slope for the centre cell e is calculated using

rise_run = √ ([dz/dx]2 + [dz/dy]2)

= √ ((0.05)2 + (-3.8)2)

= √ (0.0025 + 14.44)

= 3.80032

slope_degrees = ATAN (rise_run) * 57.29578

= ATAN (3.80032) * 57.29578

= 1.31349 * 57.29578

= 75.25762

The integer slope value for cell e is **75** degrees.

59	56	59
71	75	70
60	63	57

Aspect

101	92	85
101	92	85
101	91	84

108	87	71
91	92	96
72	96	114

Aspect of elevation
- Flat (-1)
- North (0-22.5)
- Northeast (22.5-67.5)
- East (67.5-112.5)
- Southeast (112.5-157.5)
- South (157.5-202.5)
- Southwest (202.5-247.5)
- West(247.5-292.5)
- Northwest (292.5-337.5)
- North (337.5-360)

The rate of change in the x direction for the centre cell e is:

[dz/dx] = ((c + 2f + i) - (a + 2d + g)) / 8

= ((85 + 170 + 84)) - (101 + 202 + 101)) / 8

= -8.125

The rate of change in the y direction for cell e is:

[dz/dy] = ((g + 2h + i) - (a + 2b + c)) / 8

= ((101 + 182 + 84) - (101 + 184 + 85)) / 8

= -0.375

The aspect is calculated as:

aspect = 57.29578 * atan2 ([dz/dy], -[dz/dx])

= 57.29578 * atan2 (-0.375, 8.125)

= -2.64

Since the calculated value is less than zero, the final rule will be applied as:

cell = 90.0 - aspect = 90 - (-2.64)

= 90 + 2.64

= 92.64

The value of **92.64** for the centre cell e indicates that its aspect is in the easterly direction.

Raster vs. TIN

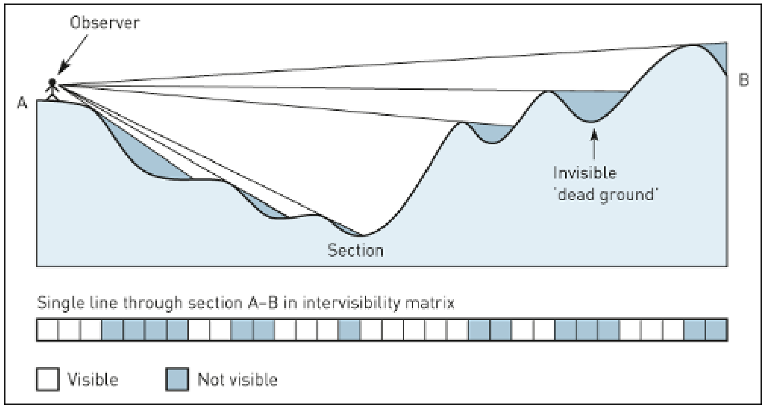
TIN

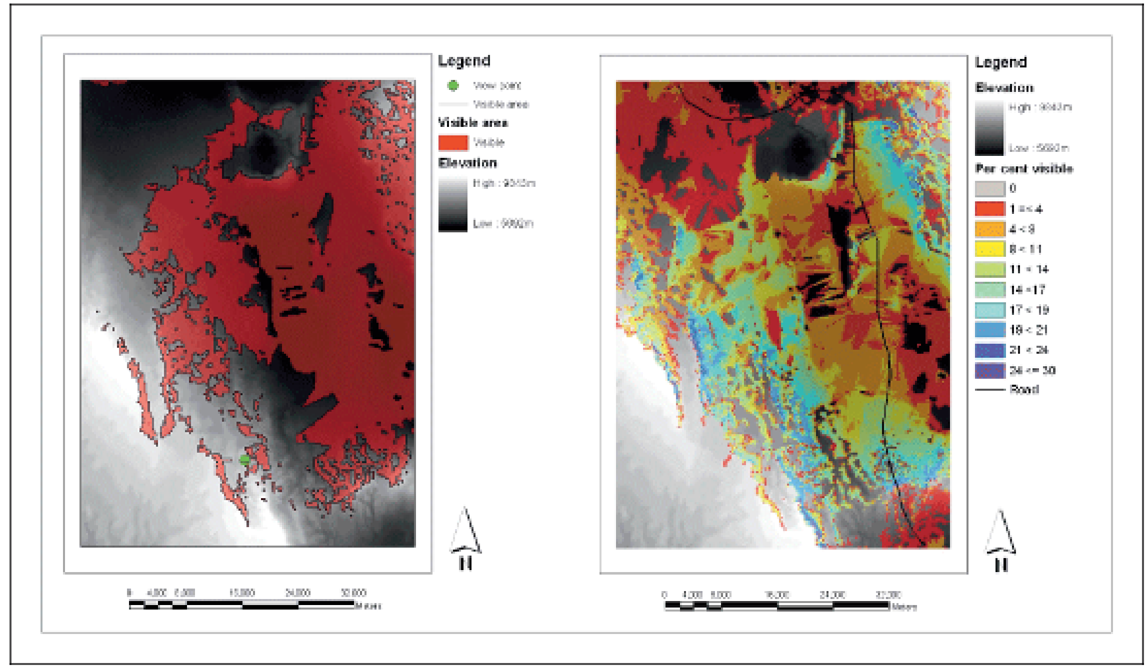
- Flexible input data sources
- Creates sharper image

Raster

- Computational efficiency

Visibility Analysis





Ray tracing for visibility analysis (left)

Results of viewshed analyses for single point and linear feature (right)

Coming next...

Interpolation

Multi-criteria Evaluation

Modeling