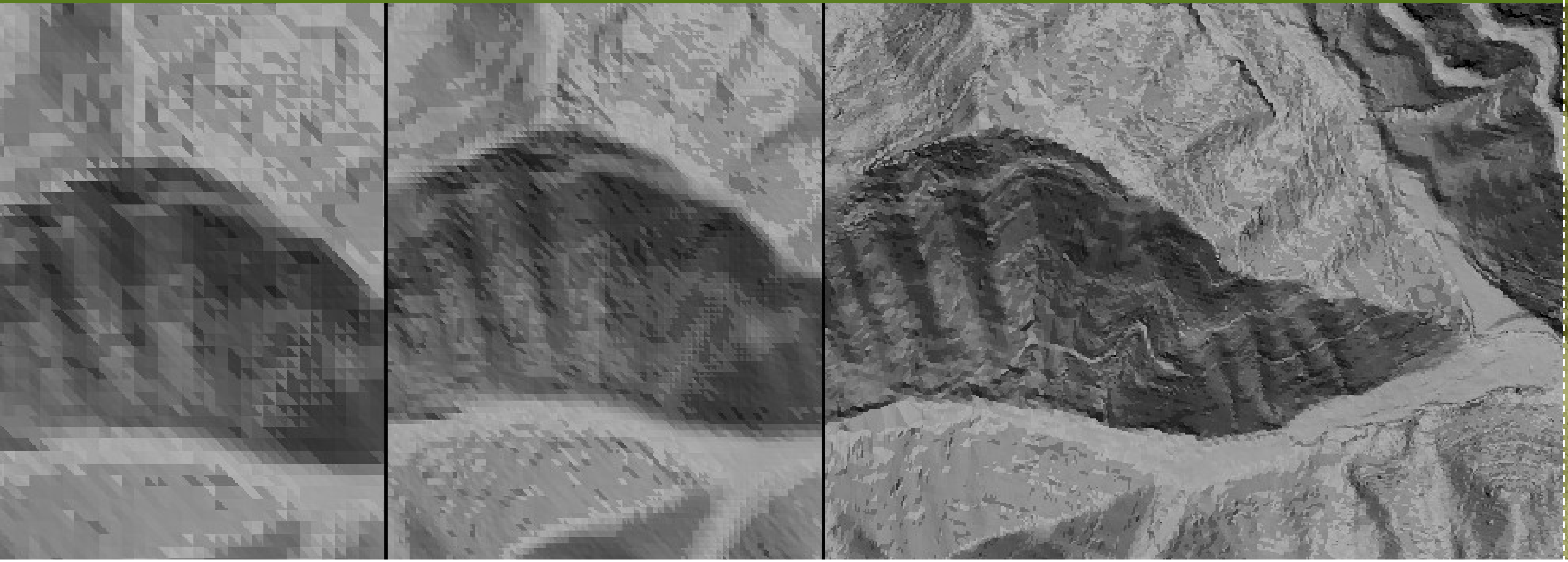
Course Overview & Digital Terrain Data Models



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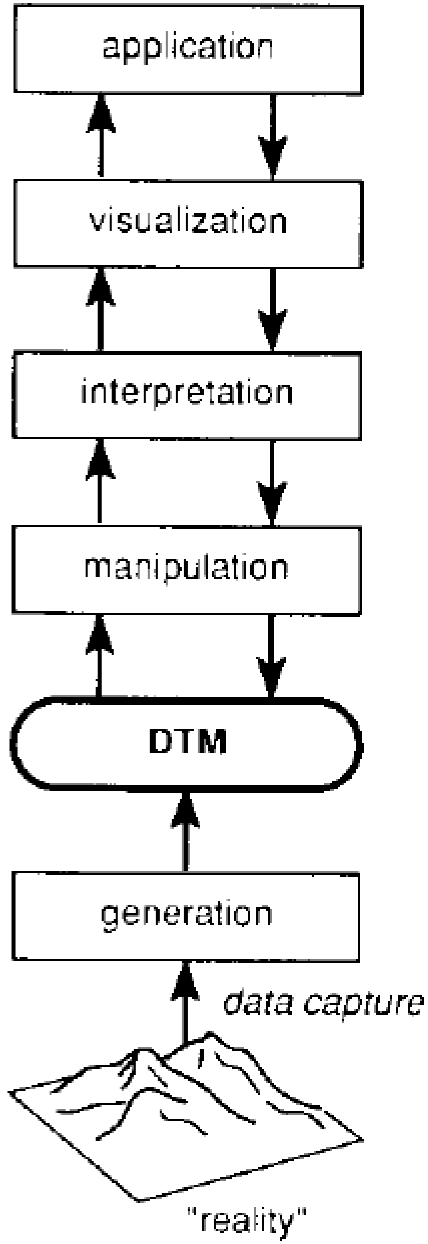

Figure 19.1 The main tasks of a digital terrain modelling system. (Weibel and Heller 1988)

Digital Terrain

A digital representation of terrain surfaces.

- 2D, 2.5D, or 3D (?)

Representation of terrain surfaces:

- Maps (graphics)
- Physical models
- Mathematical models
- Digital terrain models

Digital Terrain Models (DTM)

- Trend surfaces (models)
- Digital contour lines
- Elevation points
- DEM
- TIN
- Object with z attribute
- Fractal

Fractal Terrain (created in Vue)

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Why are DTMs Required?

- Geographic processes
  - Watershed
  - Drainage network
  - Slope, aspect (solar illumination)
  - Viewshed
  - Analyzing volumetric change
  - Orthorectification
  - 3D simulation and visualization
  - ...

Digital Terrain Surface Modeling

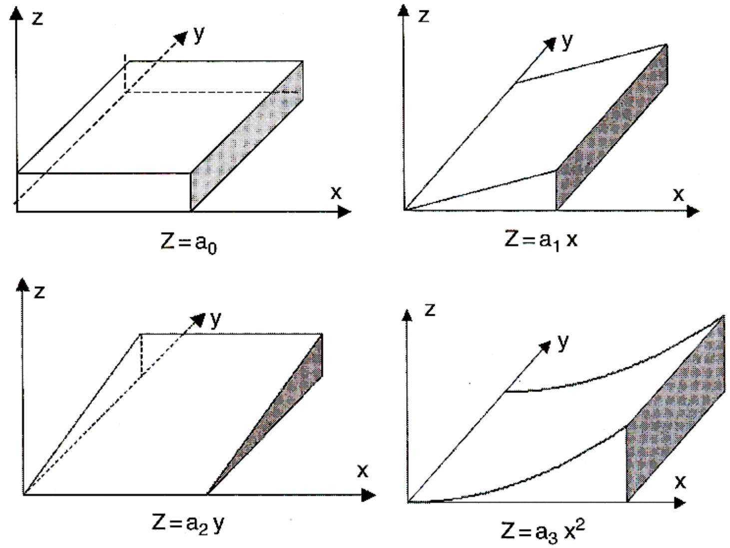
- Data features (points, triangles, grids)
- Surface models
  - Surface interpolation
- Surface reconstruction

Trend Surface Analysis

Data features: points

Surface models: Polynomial Functions

Individual Terms	Order	Descriptive Terms	No. of Terms
$Z = a_0$	Zero	Planar	1
$+a_1X + a_2Y$	First	Linear	2
$+a_3X^2 + a_4Y^2 + a_5XY$	Second	Quadratic	3
$+a_6X^3 + a_7Y^3 + a_8X^2Y + a_9XY^2$	Third	Cubic	4
$+a_{10}X^4 + a_{11}Y^4 + a_{12}X^3Y + a_{13}X^2Y^2 + a_{14}XY^3$	Fourth	Quartic	5
$+a_{15}X^5 + a_{16}Y^5 + a_{17}X^4Y + a_{18}X^3Y^2 + a_{19}X^2Y^3 + a_{20}XY^4$	Fifth	Quintic	6



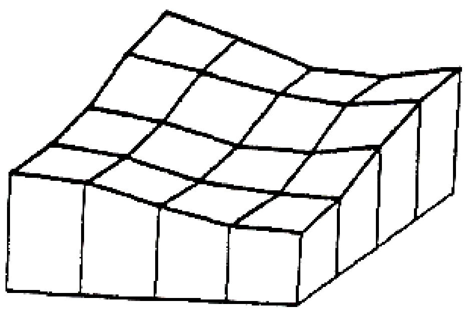
Minimum Number of Points to Construct a Surface

$$N = \frac{(t+1)(t+2)}{2}$$

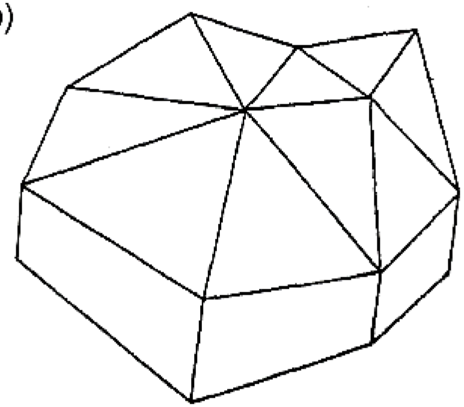
Order (t)	Type	Min # Pcts
0	Planar	1
1	Linear	3
2	Quadradic	6
3	Cubic	10
-	Bi-linear	4

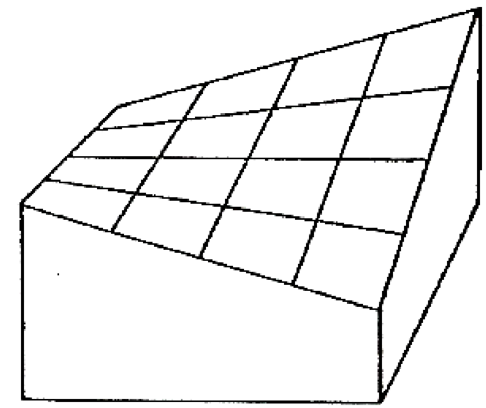
Bilinear Surface & Bilinear Interpolation

(a)

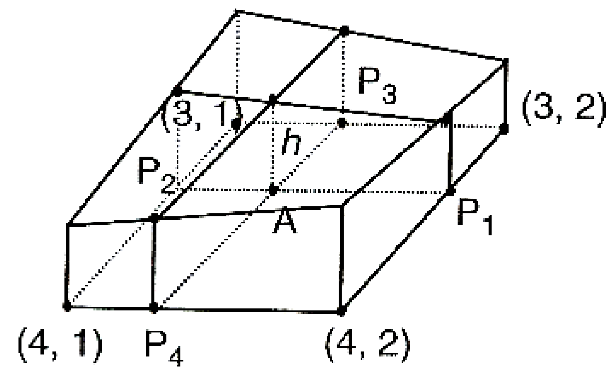


(b)





(a) Surface formed by bilinear surfaces
(b) Surface formed by triangles



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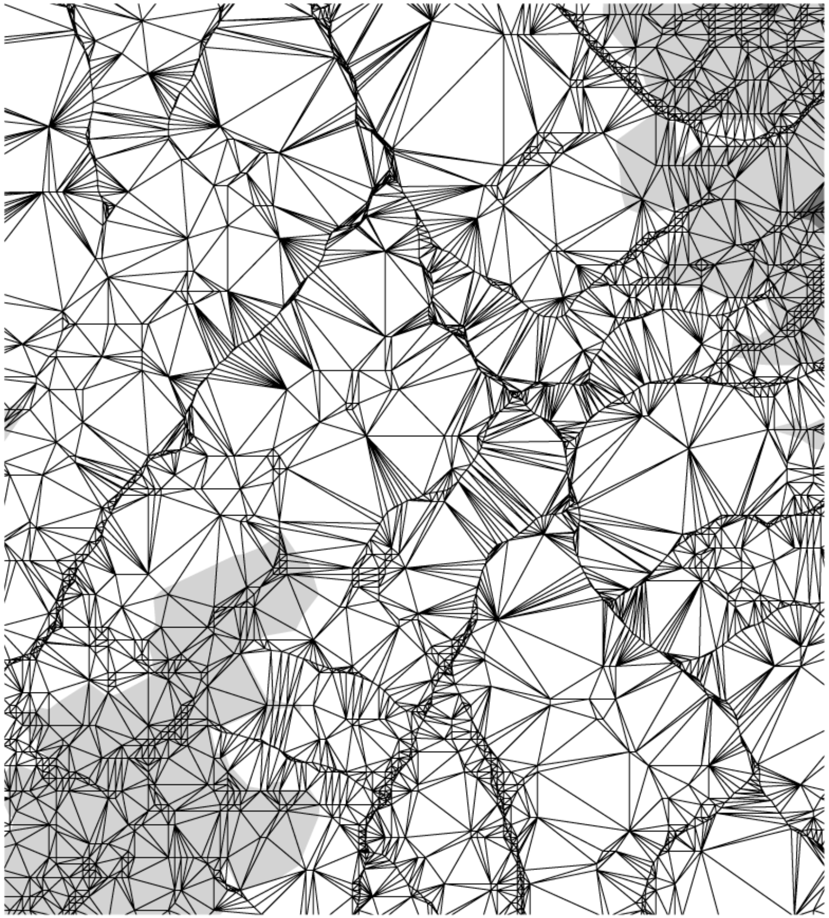
Triangulated Irregular Network (TIN)

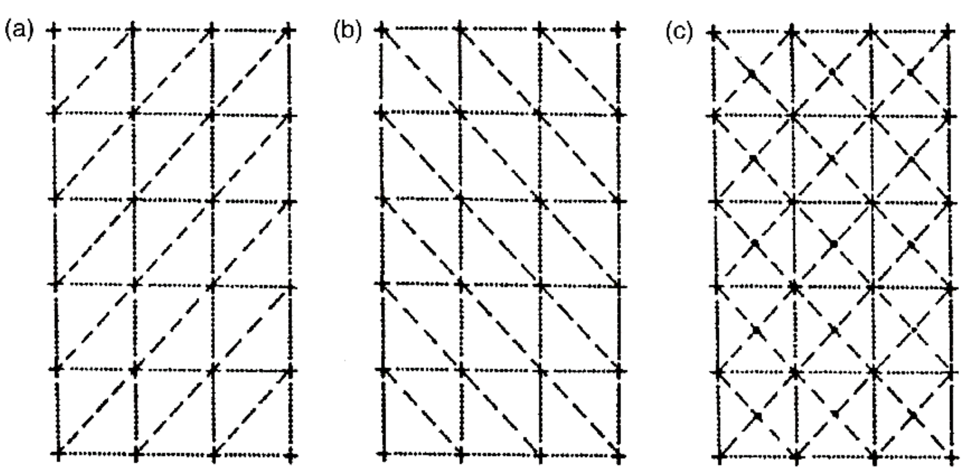
- Node (x, y, z)
- Edge
- Triangles
- Topology
  - The triangle number
  - The numbers of each adjacent triangle
  - The three nodes defining the triangle
  - The x, y coordinates of each node
  - The surface z value of each node
  - The edge type of each triangle edge (hard or soft)

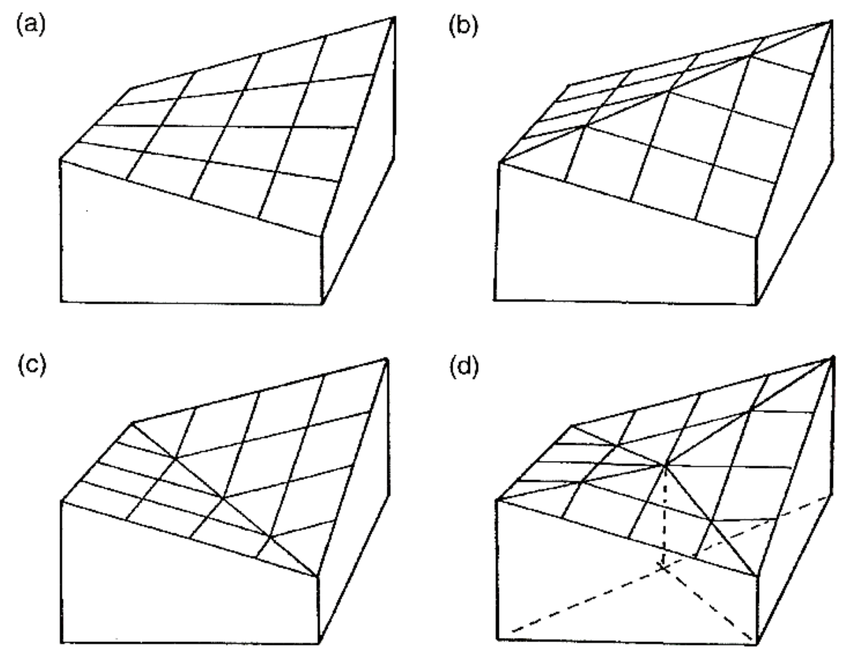


Hybrid Surface Modeling

Triangular regular network

- Formed from regularly distributed data





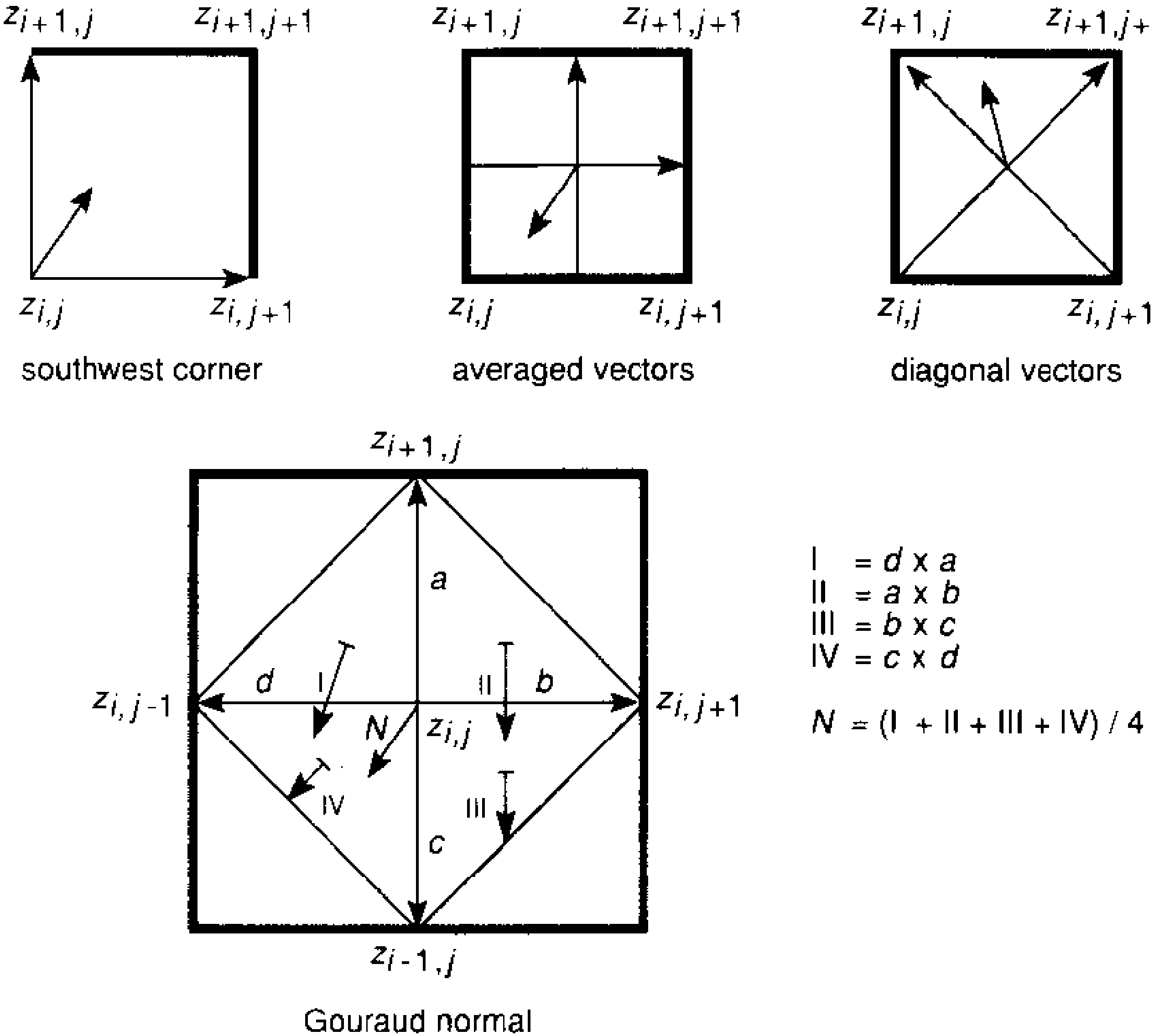


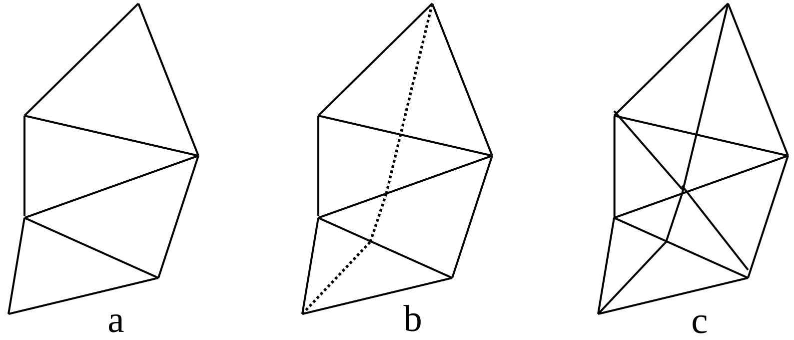
Fig. 19.11 Several alternatives to obtain averaged surface normals for square patches of either four or nine adjacent grid points.

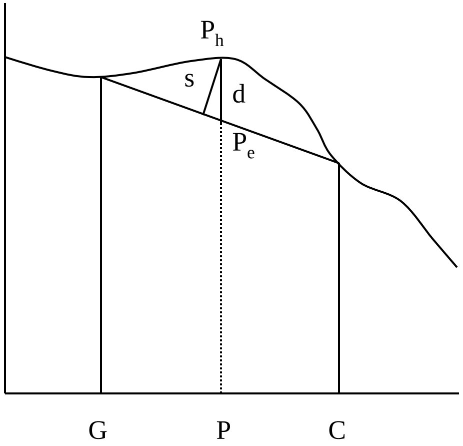
Conversions between Surface Models

From \ To	Point	Triangle	Grid
Point	Spatial interpolation	TIN generation	Spatial interpolation, indirect interpolation
Triangle	Edge points	-NA-	Linear / curved surface interpolation
Grid	Nearest neighbor, linear/cubic interpolation	TIN generation	Nearest neighbor, linear/cubic interpolation

Generating TIN

- Selection of significant points from DEM
  - Very Important Points (VIP)
  - Maximum z-tolerance
- Delaunay triangulation
  - Mass points (->TIN nodes)
  - Breaklines - soft (form), hard (->TIN edges)





DEM & DSM

DEM: Digital Elevation Model (ground elevation)

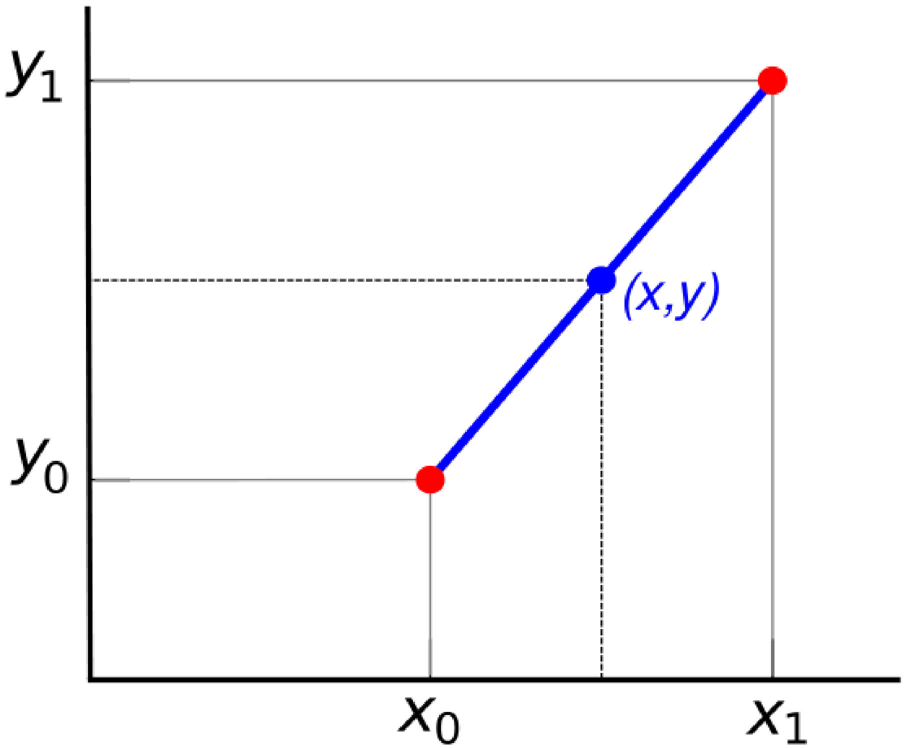
DSM: Digital Surface Model (surface elevation, including trees, buildings, houses, etc)

Math Review

Similar triangles

http://www.mathopenref.com/similartriangles.html

Known: x_0, y_0, x_1, y_1, and x
Find: y



Example:

x_0, y_0 = 3, 2
x_1, y_1 = 6, 6
x = 4
y = ?