An Irregular Tessellated Surface Model
Map Algebra to Define Flow Directions
and Delineate Watershed Boundaries
Using LiDAR Bare Earth Sample Points

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Outline

Background Information
Data
Motivation

Methods
Python Algorithms
Flow Directions
Basin Delineation
Sink to Basin Aggregation
Sink-in-Sink to Basin Aggregation

Results & Future Work
Raster results vs. TIN results.
Study Area and Data

- 2005 LiDAR Data
  - Horizontal Accuracy +/- 15 – 40 cm
  - Vertical Accuracy +/- 20 - 60 cm
  - 49,000,000 million sample points
  - Samples per 100 ft² = 5
  - 2 ft Contour National Map Accuracy Standards
  - Washington State Plane North (Feet)

- Hydrography (lines)

- Culvert Locations (points)
Raster Surface Model
Flow Comparison

Vertical Relief = 17 ft

Flow Accumulation
3 foot DTM

Flow Accumulation
1 foot DTM
Error Introduced by the DTM

• Interpolation From Sample Points
  • Over Estimations of Cell Values.
  • Underestimation of Cell Values.

• Fill Tools Results in Flat Areas.

• Flow Direction Constraints (D8 Algorithm)
• D8 fails on flat surfaces
Flow Directions From Irregular Tessellated Surfaces

- Voronoi
  - Size Limit on Voronoi Surface
  - Geometry Overburden

- TIN
  - Same Spatial Relationship Between Points
  - Minimal Geometry Overburden
Flow Direction

- Created using Python.
- TIN Edges Geometry Include x, y, z Values of Line Ends.
- X, Y, Z of line ends are use to calculate distances and slopes.
- Lines are sorted base on from node x, y and slope.
- For each node, identify the steepest path out.
- Write results to a new feature class.
TIN with Flow Directions

• From Node –
  To Node == flow directions.

• Each line == record in a feature class
Basin Delineations

• Identify nodes with no outflow (sink bottoms, or pour points)

• Group connected flow direction lines and assign a basin ID.

• Spatially join TIN triangles to grouped basin lines.

• For triangles joined to 2 or more basins, export vertices.

• Create Voronoi diagram.

• Join to flow direction lines (basin grouped) to Voronoi Diagram

• Dissolve by basin ID.
Flow Directions Grouped By Basin

- Flow lines grouped by connectivity
- Assigned a nominal ID for each basin
TIN Triangles Joined With Two or More Basin Flow Paths

- TIN Triangle between basin lines identified
- Used to extract vertices
Voronoi Polygons From TIN Triangles Vertices Joined With Two or More Basins

- Spatially joined with flow direction lines
Final Basin Delineation

- Some lines intersect or cross basin boundaries
Final Basin Delineation

• Area with low spatial relief result in a large number of sinks
Sinks

- Identify basins not touching convex hull.
- Select TIN edges intersecting crossing sink basins.
- Find lowest path out of each sinks.
- Collect the FIDs of all basins connected by lines. Merge basins.
Final Basin Delineation

- Sinks with flow path out of sinks.
- Identify the basin ID for each lines to-from nodes
- Reassign basin identifiers
Final Basin Delineation

- Final basin delineation and 4 raster delineations
Comparison of Low Relief Surface Models

Pixel Size = 2 ft x 2 ft
Relief = <10 feet.
Comparison of Low Relief Surface Models

Pixel Size = 2 ft x 2 ft

Relief = <10 feet.
Comparison of Low Relief Surface Models

Pixel Size = 30 ft x 30 ft

Generated from 12500 points

Relief = <10 feet.

Basins From a 30 x 30 ft Surface Model
Comparison of Low Relief Surface Models

Pixel Size = 3 ft x 3 ft

Generated from 12500 points

Relief = <10 feet.

Basins From a 3 x 3 ft Surface Model
Comparison of Low Relief Surface Models

Generated from a 12500 node TIN

Relief = <10 feet.

Basins From TIN with ~12500 nodes
Raster VS TIN

• Raster is Faster, Vector is ‘Corrector’

• Raster = LiDAR 3 ft DTM to basins in ~1 day

• Raster = interpolation and cell size return different delineations.

• Vector = Best delineation given the LiDAR data.

• Vector = ~2000 node TIN to basins in minutes

• Vector = ~10000 node TIN to basins in an hour

• Vector = ~75000 node TIN to basins in 24 hours
References


