Conservation Applications of LiDAR Data

Workshops funded by the Minnesota Environment and Natural Resources Trust Fund
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Conservation Applications of LiDAR Data

Training Modules:

**Basics of Using LiDAR Data**

Terrain Analysis

Hydrologic Applications

Engineering Applications

Wetland Mapping

Forest and Ecological Applications

tsp.umn.edu/lidar
Basics of Using LiDAR Data

Funded by the Minnesota Environment and Natural Resources Trust Fund
Introduction

Intended as the first in a series of workshops related to LiDAR and allied analyses, “Basics of LiDAR” will serve as both a prerequisite and jumping-off-point for following workshops:

• Terrain Analysis
• Hydrologic Applications
• Engineering
• Wetland Mapping
• Forest and Ecological Applications
Lecture 1 – Raster Data

Credit – Tim Loesch - MNDNR
About Raster Data
Raster Data

- Less used today than the vector data model
- Raster environment and principles not as well understood
- Most users familiar with aerial photos or satellite imagery
Raster Data

Structure/Model
- Regular set of cells in a grid pattern
- Typically square
- Attribute values associated with each location (cell)
- Models “continuous” data well

Key features
- Cell size
- Units
Raster Data Analysis - Advantages

- History
- Flexible
  - Data structure
    - Wide range of variables
    - Simple to complex – single cell, networks, groups of cells
  - Well-developed
    - Wide variety of applications
- Continuous Data – i.e. elevation

Credit – ESRI
Raster Data Analysis – Disadvantages

- Precision limited to cell size
  - Tradeoff – higher resolution comes at greater storage cost and speed of processing
- “Stairstep” edges
- Often assigned a single “value” for a single attribute rather than a host of attributes per cell

Credit – ESRI
Raster Data Analysis

- Basic to complex
- Mathematical (Map Algebra), neighborhood (moving window) distance, surface, statistical, etc.
Map Algebra – Raster Calculator

- Raster layers combined via mathematical combinations
- Cell-by-cell – added, subtracted, divided, or multiplied

Variety of uses

- Change detection – e.g. year 2000 data subtracted from year 2010 data
- Terrain attributes – e.g. SPI – multiply effect of one variable by another
Raster Data Analysis

Neighborhood Functions

- Moving window of cells swept across all raster cells, typically multiplying values by data found around center cell
- Very common in raster analysis
- Slope, hillshade, filter, and kriging calculations for example, all employ a moving-window approach
Working with Raster Data
Working in the Raster Environment

Raster = Grid

- File Structure
- Grid Alignment
- Resampling
- Aggregation
File Structure

Arc GRIDS are not single files

- Several folders with associated files
- Linked – cannot work independent of one another
- Use ArcCatalog to copy, move or rename
- Can export into variety of single file-types - .img, .e00, etc.
Grid Alignment

Proper Grid Alignment = Snap Raster Settings

Snap Raster Setting

- The cells in the output raster are aligned with the cells of the snap raster.
- The lower-left corner of the extent is snapped to a cell corner of the snap raster.
- The output cell size is same as the snap raster cell size.

Credit – Sean Vaughn- MNDNR
Resolution

Cell size should be same for all inputs

If not →

- Nearest neighbor resampling automatically occurs
- Resampled to coarsest resolution of all inputs
- Esp. not recommended for continuous data – i.e. Elevation
Aggregate/Resample

- Changing the resolution (Upscaling) – if cells evenly divisible, use AGGREGATE
- If not evenly divisible or changing the alignment, then use RESAMPLE
- You can downscale, but this does not create any new information

Credit – Sean Vaughn - MNDNR
Elevation Data - DEMs
Raster Elevation Data Sources

- Stereo photography
- Topographic maps (elevation contours)
- Ground survey (GPS, other)
- LiDAR
Stereo Photography

- View shape of topographic surface
- Overlapping photographs
- View from two perspectives (parallax)
- Old technology – has been used extensively in Soil Survey and forestry

Credit – Steve Kloiber- MNDNR
Topographic/Contour Data

- Also called contour maps
- Contour line joins points of equal elevation
- Can interpret slope, relief, shape/size of valleys and hills
- Paper and digital
  - Digital leaves visualization up to the user
Survey

- GPS survey or Total Station
- Small areas
- Labor intensive
- Very precise
Raster Elevation Data Formats

Models of Topography

- Multiple ways of representing elevation
  - Triangulated irregular network
  - Contours (Vector)
  - Digital elevation model (Raster)

Each has advantages and disadvantages

DEM is used most often for terrain analysis and watershed delineation

Credit – Steve Kloiber- MNDNR
Digital Elevation Model (DEM)

What is a DEM?

- Digital file that:
  - Contains elevation of terrain over a specified area
  - Is arranged as a fixed-grid interval over the earth surface
  - Is geo-referenced
  - Can be manipulated to create other elevation-dependent data products
Digital Elevation Model (DEM)

- Consists of pixels or cells
- Value assigned represents average elevation of grid cell

Credit – Steve Kloiber- MNDNR
Digital Elevation Model (DEM)

DEMs are a common way of representing elevation where every grid cell is given an elevation value. This allows for very rapid processing and supports a wide-array of analyses.

Credit – Steve Kloiber - MNDNR
DEM Characteristics

Resolution

- Density of elevation measurements
- Determines level of detail of surface representation
- 30m coarse – 1m fine

Interpolation

- Calculation used to find elevation of unspecified location
- Various techniques/algorithms: Kreiging, Theissen Polygons, Spline, IDW, Bilinear, Nearest Neighbor
Effect of Cell Size - Resolution

Coarse Resolution

Fine Resolution
DEM Comparison

Why so much interest in LIDAR?

• Higher resolution data than we ever thought possible
• Opens up opportunities to describe and characterize landscapes in ways previously not feasible

Comparison to existing national standard product

<table>
<thead>
<tr>
<th></th>
<th>USGS DEM</th>
<th>LiDAR DEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal Resolution</td>
<td>30 meters</td>
<td>~1 meter</td>
</tr>
<tr>
<td>Vertical Resolution</td>
<td>7-15 meters</td>
<td>~15 cm</td>
</tr>
<tr>
<td>Contour Interval</td>
<td>5-20 feet</td>
<td>1-3 feet</td>
</tr>
</tbody>
</table>
DEM Resolution Tradeoff

Lower resolution = faster processing

Higher resolution = more precision, maintains small features
DEM Comparison

USGS 30m DEM

LiDAR 3m DEM
LiDAR Derived DEM
Cell Size: 1 meter sq
Vertical Error: 15 cm
1.5 mil points / sq mile

USGS Standard DEM
Cell Size: 30 meter sq
Vertical Error: “Equal to or better than 15 m.”
1600 points / sq mile

¹ Varies based on project specifications

Credit – Tim Loesch - MNDNR
LiDAR 3 meter Elevation Data
Hillshade DEM
3m vs 30m
Contour Comparison – Vector Product

2 ft contours created from LIDAR data

10 ft contours created from standard 30m DEM data
End of Lecture 1

Questions/Comments?
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