Lidar Analysis in ArcGIS: An Introduction

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Arthur Crawford
ARCGIS IS A LiDAR PLATFORM
Empowering you to make informed decisions from remotely sensed data
Data Structures for lidar support in ArcGIS

- File01.las
- File02.las
- ... File99.las

Multiple files/folders

- Analyze and update
  - LAS dataset / Terrain dataset
- Manage, serve, share
  - Mosaic dataset / point cloud scene layer
Application Fusion: ArcGIS Pro

- ArcMap
- ArcCatalog
- ArcGlobe / ArcScene
Lidar data storage – zLAS

- Introduced January 2014
- Compression, sorting, and indexing
- Direct read
  - Parallel decompression added to ArcGIS apps in 10.3
- Features & Benefits
  - Re-sequence points w/ geospatial index
  - Optimized for random access
  - Lossless compression
  - Transparent integration with LAS dataset
Lidar data with a LAS dataset

- Direct read of LAS or zLAS format lidar
- File based
- QA/QC tools
- Stores references to LAS/zLAS files on disk
- Optionally reference breakline and control point data
- Treats a collection of LAS/zLAS files as one logical dataset ("Project")
Create a LAS dataset

- Interactively through ArcCatalog
  - Use the file folder context menu

- Using scripts and models with geoprocessing tools
LAS file based statistics

- LAS Dataset Properties: LAS File Statistics
QA\QC: LAS dataset based statistics

- LAS Dataset Properties: LAS Dataset Statistics

![LAS Dataset Properties](image)
ArcGIS Pro: LAS Dataset Properties

LAS Dataset Properties: LAS Dataset.lasd

**General**

- **Name**: LAS Dataset
- **LAS Files**: 16 (16 LAS files, 0 2LAS files)
- **Surface Constraints**: 0
- **LAS Points**: 157,486,819
- **Data Size**: 4,205.37 MB
- **Uncompressed Size**: 4,205.37 MB

**Extent**

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<th>Maximum</th>
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<td>Y</td>
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**XY Linear Unit**: Foot_US

**Z Unit**: Foot_US
Edit classification codes: ArcMap

- Interactive
  - Fixing data anomalies and misclassifications via point profile window
- Automated (GP tools)
  - Classify relative to feature data
  - Reclassify to standard LAS specification
Edit classification codes: Pro
Polygon Volume

- Enhance existing geoprocessing tool to support LAS dataset as input surface. Current support limited to TINs and Terrains.
- Use of drones to collect photogrammetric point clouds to measure volumes for things like stockpiles is increasing rapidly.
- LAS dataset is a natural fit for this data so direct support in this tool improves productivity and usability.
Classify LAS Noise

- New GP tool to classify noise points in lidar.
- Erroneous points are caused by a variety of things such as haze, birds, and water.
- Present at least to some degree in all lidar collections.
- Noise interferes with display and processing of the data.
- This is a fundamental capability.
Classify LAS Overlap

- New GP tool to assign the overlap flag/code to points in areas of overlap between flight lines.
- Area of overlap introduces high frequency noise to ground which interferes with creation of high quality DEMs. It’s therefore desirable to exclude the overlap.
- Tool is needed to help improve quality of DEMs ArcGIS can produce,
LAS Point Statistics By Area

Input LAS Dataset
Input Polygons

Include Standard Deviation (optional)

Table:

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<th>ZMax</th>
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Legend: (08 out of 1006 Selected)
Classify LAS by Height

**Height Above Ground**

**Input LAS Dataset**

Define height breaks and associated classes

<table>
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<tr>
<th>Class</th>
<th>Height</th>
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<td>5</td>
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<tr>
<td>4</td>
<td>25</td>
</tr>
<tr>
<td>5</td>
<td>50</td>
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</tbody>
</table>

- Use just model key points for ground (optional)
- Model key type (optional)
  - **Code based**
- Reclass points below ground to noise (optional)
- Reclass points above max height to noise (optional)
- Classify within processing extent only (optional)
- Calculate statistics (optional)

**Profile View**
Locate LAS Points By Proximity

Data courtesy of PhotoScience
Locate LAS Points By Proximity
Lidar/3D Sample Tools

- Available in ArcGIS 10.2 – 10.5
- Sample geoprocessing tools
  - [http://links.esri.com/3dSamples](http://links.esri.com/3dSamples)
Demo

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Best Practices

- Tiled LAS, v1.1 or higher
- Projected, rearranged, indexed
  - zLAS
- File size: 1 – 2 GB or less (<500 MB if not rearranged)
- Keep file I/O local, avoid network
- Study area boundary included as constraint
- Airborne lidar
  - Classified (bare earth, non-ground)
  - Breaklines for hydro enforcement
- Terrestrial lidar
  - RGB & intensity values, classified

* Also applies to photogrammetric point clouds
Rearranging Point Records

Spatial distribution of points

Physical location in file
Rearranging Point Records

Spatial distribution of points

Physical location in file
Indexed 3d Scene Layer (I3S)

- Specification:
  - https://github.com/Esri/i3s-spec
  - Point cloud scene layer – lidar data
  - Integrated Meshes – surface model
  - 3D objects – 3D models
  - Point features - schools, hospitals, signs
Lidar Building Footprint Extraction

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Lidar Building Footprint Extraction
Collection Building Footprints for Content and tools to share with contributors

- Millions of buildings have been collected so far.
- Tools and processes developed were put into a toolset.
- Cleaning tools developed for Regularizing buildings
- Lidar Classified for Buildings (Code 6) Extraction
- Lidar Unclassified for Buildings Extraction
  - Uses Bone Map in background
Bone Map

- Dr. Thomas Pingel (University of California, Santa Barbara) developed the Bone Map using a Shaded Slope.
- Instead, we use a multi-directional hillshade with a mask of areas below a height. Similar result.
- Fill in center of the building using a statistics minimum
- Remove trees with there texture (darkness) using remap

Images supplied by Dr. Pingel, below and to right.
Extract Building Footprints from LiDAR that is not classified for buildings

Tools that:
- Create a set of tiled surfaces from lidar
- Load tiled surfaces into a Mosaic Dataset
- Apply Raster Functions to analyze data
- Convert results to vector data
- Cleanup artifacts and perform generalization (regularization)

Raw LiDAR

DTM and DSM creation

Draft polygons

Final Building Footprints
Lidar Point Cloud not classified for buildings
Lidar Raster Tile (DTM)

1) Create DSM and DTM Raster Tiles With Buffer
2) DSM and DTM to Composite Mosaic Dataset
3) Replace Mosaic Dataset Processing Templates
4) Extract Draft Building Footprint Polygons
5) Regularize Draft Building Footprint Polygons
6) Batch Regularize Draft Building Footprint Polygons
Lidar Raster Tile (DSM)

- Create DSM and DTM Raster Tiles With Buffer
- DSM and DTM to Composite Mosaic Dataset
- Replace Mosaic Dataset Processing Templates
- Extract Draft Building Footprint Polygons
- Regularize Draft Building Footprint Polygons
- Batch Regularize Draft Building Footprint Polygons
Raster Functions and then Draft Building Footprints

- Extract Building Footprints from LiDAR Unclassified for Buildings
- Replace Mosaic Dataset Processing Templates
- Extract Draft Building Footprint Polygons
- Regularize Draft Building Footprint Polygons
- Batch Regularize Draft Building Footprint Polygons
Final Building Footprints (Regularized)

- Extract Building Footprints From Lidar Unclassified For Buildings
- 1) Create DSM and DTM Raster Tiles With Buffer
- 2) DSM and DTM to Composite Mosaic Dataset
- 3) Replace Mosaic Dataset Processing Templates
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- 5) Regularize Draft Building Footprint Polygons
- Batch Regularize Draft Building Footprint Polygons
Extract Building Footprints from LiDAR that is classified for buildings

Python scripts and ArcGIS Models that:
- Convert LiDAR to LAS Dataset
- Create a set of tiled surfaces (DTM, DSM)
- Load tiled surfaces into a Mosaic Dataset
- Apply Raster Functions to analyze data
- Convert results to vector data
- Cleanup artifacts and perform generalization

Raw LiDAR → LiDAR Raster Tile → Draft polygons → Final Building Footprints
Overview

The Local Government 3D Basemaps is a set of ArcGIS Pro projects that can be used to author high-quality 3D scenes for your local government. These scenes are organized in different Levels of Detail (LOD) and derived from 2D operational data managed by a department or agency within a local government. Once authored, the 3D scenes are a foundation for 3D workflows and applications; and provide a consistent geographic context across local government departments and agencies.
Demo

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Future tools to improve the Process:

- After draft building collection, use Intersect with Parcel data
- Use NDVI with 4 band imagery and Zonal Statistics
- Use Texture of the DSM (TPI) and Zonal Statistics
- A tool to identify and possibly fix jagged edges at non 45 or 90 degree edges
Issues with Extraction – the Good, Bad and Ugly:

**Bad:** Individual Buildings that come out bad with extraction from classified lidar

Complex Industrial Areas

Homes
Ideas for Improving tools for better extracted buildings:

1. Create a Parcel Building Intersect Tool that will allow Intersect with buildings or clipping using buffered parcel lines.
2. Processes for automated clean up of non-building using NAIP NDVI and DSM Texture (TPI Roughness).
3. We need a tool that will align small buildings near to the road features. Fix issues with angle alignment.
4. Tools to identify features with stair stepping.
Regularize Draft Building Footprint Polygons tool works with High Resolution Land Cover

Example is from the open data Chesapeake Conservancy Land Cover with Delaware Parcel data used for Intersect with draft building polygons. (http://chesapeakeconservancy.org/conservation-innovation-center/high-resolution-data/land-cover-data-project/)

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