Idaho State University

Case Study: Classifying Big Crater Ring LiDAR for Golden Eagle Habitat Suitability Analysis

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Introduction

In the West, golden eagle nesting sites are commonly found near cliffs, such as the Big Crater Rings near Mountain Home, Idaho. However, their population is declining due to the effects of climate change and increased human presence. This case study used raw LiDAR data obtained from a DJI Zenmuse L1 and UAS photogrammetry data from one of the crater rings.

LiDAR Data Preparation and Processing

Data Conversion

The raw LiDAR data was converted to a *.las* (LAS) file format using DJI Terra. The LAS file format is a public file format for 3D point data developed to allow for the exchange of LiDAR point cloud data. The American Society of Photogrammetry and Remote Sensing approves the format specifications. The more current specification is LAS 1.4, which was updated with Revision 15 on July 9, 2019. The LAS file output from DJI Terra is 1.2, so it was converted from LAS 1.2 to 1.4 using the las2las tool by LAStools. The output was saved in a *.laz* (LAZ) file format. LAZ is a compressed LiDAR data file format.

Strip Alignment

LiDAR systems rely on GPS and an inertial measurement unit (IMU) to calculate the distance traveled by emitted and reflected light. The GPS supplies the locations of the aircraft, and IMU provides the orientation. The IMU consists of three gyroscopes and three accelerometers, one each for yaw, pitch, and roll. In simple terms, it measures rotation and acceleration to determine changes in aircraft position. The IMU continuously adds detected changes to the current position. Measurements, as well as errors, are accumulated over time.

The crater ring LiDAR data was collected in strips. The strips overlapped and did not align on the edges, resulting in seamlines and steps not representative of the terrain. The strips needed to be aligned to accurately classify all collected data as a whole. The StripAlign tool from BayesMap Solutions was used to do this. According to BayesMap Solutions, the tool “registers overlapping LiDAR swaths and corrects both relative and absolute geometric errors.” It also reduces inconsistencies between strips due to IMU errors.

The flight lines were cut using StripAlign to remove the areas where the aircraft was turning and keep only the flat flight lines. The inputs for this process were the smoothed best-estimated trajectory (SBET) files from the flight and LAZ file. A LAZ file for each flight line cut was output, as well as smaller flight line cuts which were manually deleted from the working files. The flight line cuts were then automatically calibrated, aligned, and registered.

Spatial Indexing

The lasindex tool was used to create a spatial index. Spatial indexing organized the point cloud into a search tree. Without spatial indexing, a sequential scan of each point must be performed when conducting a spatial query. With spatial indexing, the query is performed faster and more efficiently because not all the data need to be scanned. To increase processing efficiency even more, the point cloud was broken into 200-meter tiles with 20-meter buffers using the LAStile tool.

LiDAR Data Classification and Data Products

The crater ring LiDAR point cloud tiles were classified into ground, vegetation, and noise classes using various tools from the LAStools software. The tile buffers were removed, and the cliff face points were classified manually. After the manual classification, the tiles were merged and exported as a LAS file.

Point Density (points/m2)	
All	543.43
Ground	195.92
Points Per Class	
Unclassified	340,548,957
Ground	193,112,524
Vegetation	95,950
Noise	255
Cliff Face	1,993,430

Table 1 - Crater ring point cloud information after classification.

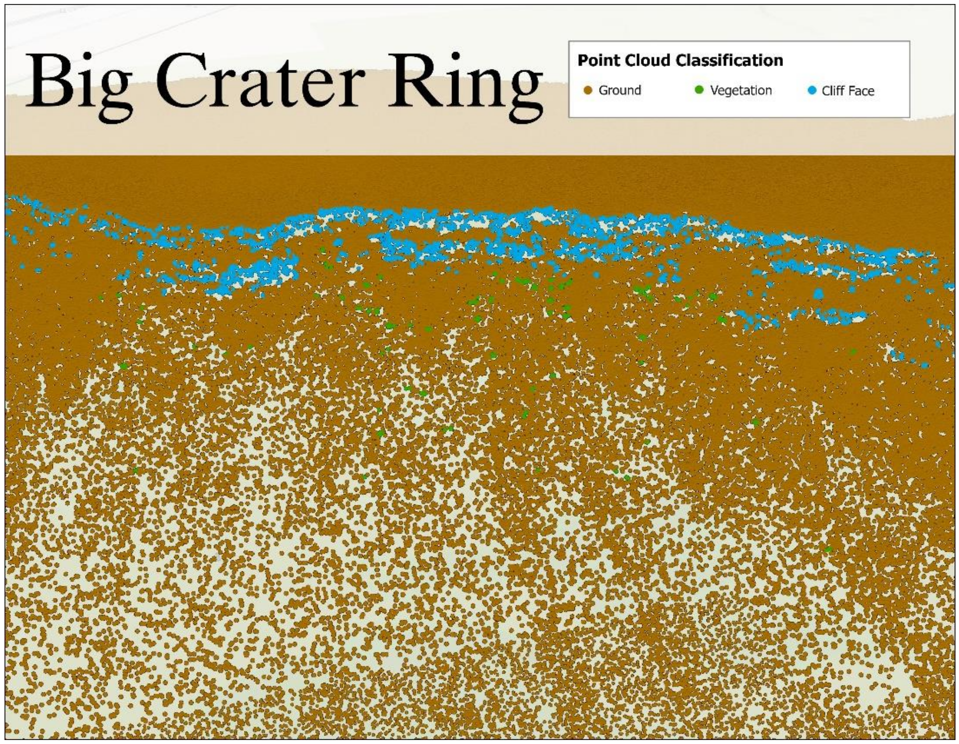

Figure 1 - Map of Big Crater Ring point cloud classification including ground, vegetation, and cliff face points.

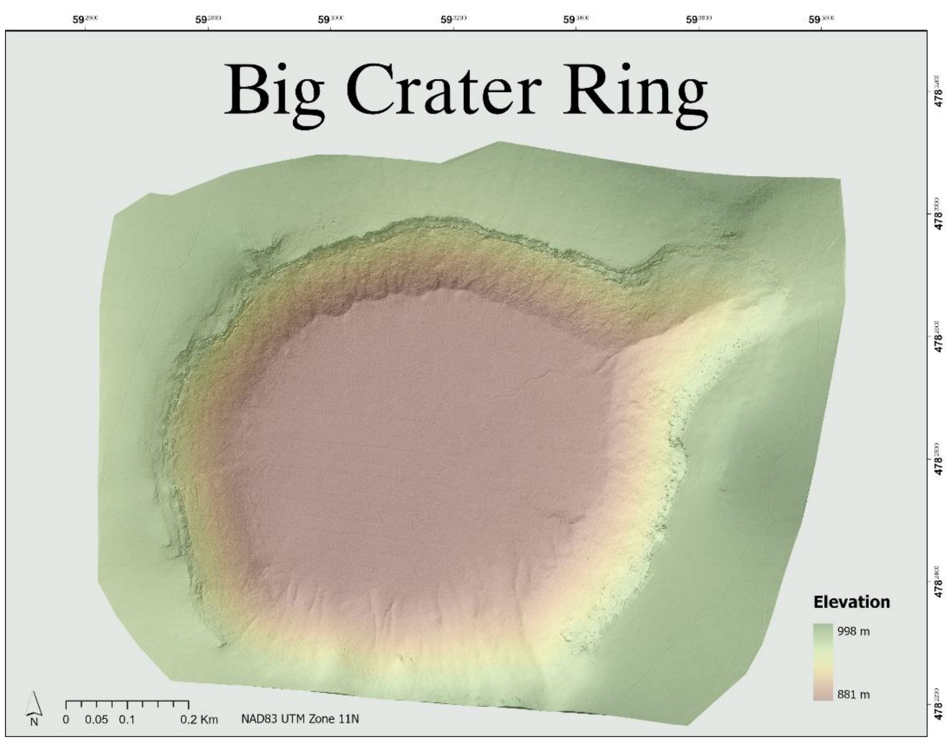

Figure 2 - Map of Big Crater Ring digital elevation model derived from LiDAR ground points.

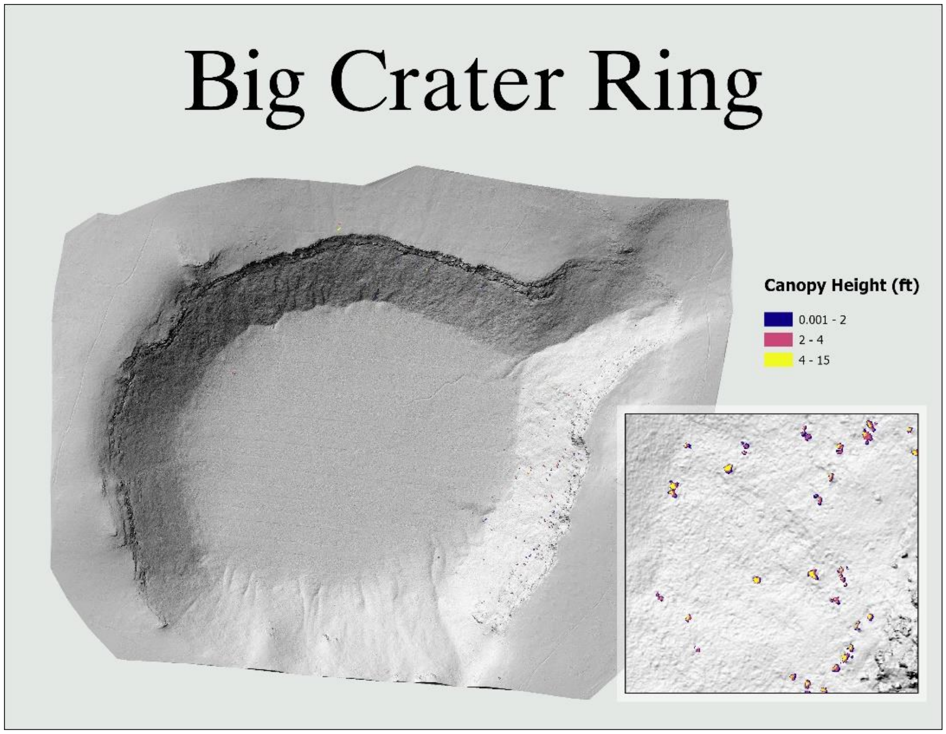

Figure 3 – Big Crater Ring canopy height map using digital elevation model and surface model derived from LiDAR data.

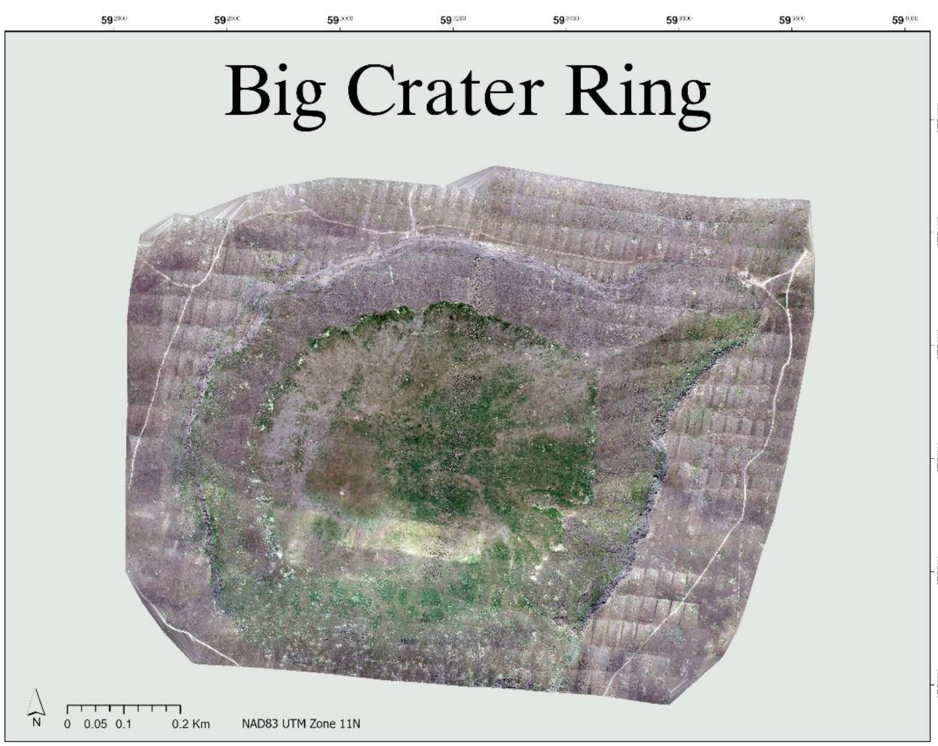

Figure 4 - Map of Big Crater Ring true color orthomosiac derived from LiDAR data.

The merged LiDAR point cloud was used with the blast2dem tool to generate a digital elevation model (DEM) using ground and cliff face points (Figure 2). A digital surface model (DSM) was also generated using ground, vegetation, and cliff face points. The DEM and DSM were used to create a canopy height model of the crater (Figure 3). Additionally, blast2dem was also used to generate a true color orthomosaic (Figure 4).

The photogrammetry and LiDAR point clouds were brought into CloudCompare for alignment. Because of the large amounts of data associated with point clouds and the processing capability of the computer used, a small portion of both point clouds was segmented to reduce processing time. A coarse alignment was performed first using four point pairs for registration with the LiDAR cloud used as the reference and the photogrammetry cloud as the registered cloud. The RMS error after the coarse alignment was 0.254069.

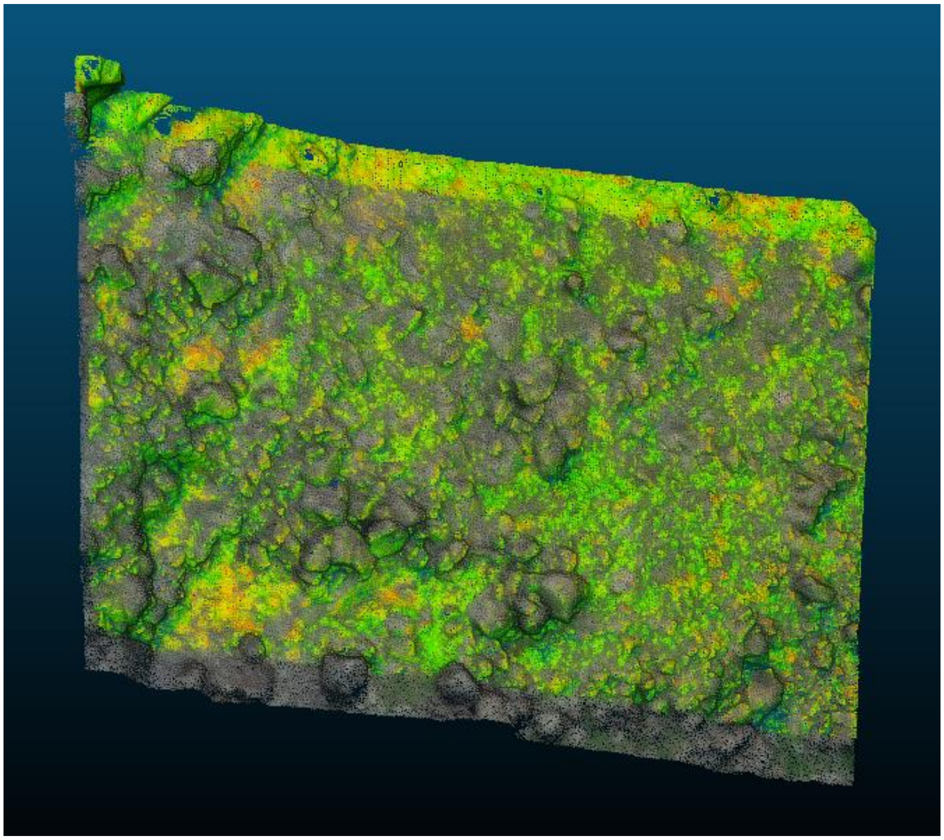

Figure 5 – Segment of photogrammetry (color) point cloud aligned with LiDAR point cloud (grey). RMS error = 0.112486.

The fine registration in CloudCompare is accomplished using the iterative closest point (ICP) algorithm. Because the algorithm relies on the two point clouds having relatively good alignment, a coarse alignment must be performed first. The ICP algorithm minimizes the root mean square errors between the clouds by first matching each registered point with the closest reference point. Then it estimates a transformation to best align each registered point with its matched reference. The transformation is applied to the registered cloud, and the process is repeated. The iterative process continues either for a specified number of iterations or until the RMS error is below a specified threshold. The RMS error after the fine registration between the LiDAR and photogrammetry point cloud was 0.112486.

Point cloud accuracy is evaluated by both absolute and relative accuracy. Absolute accuracy is how closely the position of a given point in a point cloud or 3D model is to the same point in the real world. Relative accuracy is how closely the point cloud or 3D model replicates the real world. For example, a point cloud of a building with high relative accuracy would have the same dimensions as the actual building even if the model does not line up in the real world. Data with high relative accuracy can be reprojected to achieve high absolute accuracy.

Discussion

The cliff face classification of the LiDAR point cloud provides one input for a golden eagle nesting habitat suitability analysis. Additional data for the location of roads, recreational trails, and human inhabitance would be needed to complete the analysis. Data regarding the foraging habitat would also be needed. A model could be created with these data and known nesting sites to predict possible nesting sites.