Landscape-Based LiDAR Data Reduction

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Abstract

One of the major challenges of using the LiDAR technology is that it produces a huge amount of data. This leads to issues not only in storing data, but also in the amount of time and energy that may take to process the data. Many studies have been conducted on LiDAR data reduction by applying a uniform reduction algorithm across the entire scene. This project performed a stratified LiDAR data reduction by different levels of terrain derived from a very-high-resolution hyperspectral imagery. The results were also used to produce a user-friendly interface as an ArcMap extension that allows users to specify varying levels of data reduction by terrain across a given LiDAR data. Results from these reductions showed promising results, including small decreases in accuracy.

Research Objectives

Main Goal

- Develop a landscape-based LiDAR data reduction method using very-high-resolution hyperspectral imagery.

Objectives

- Derive an accurate land cover map from a very-high-resolution hyperspectral data by classification algorithms.
- Develop a landscape-based LiDAR data reduction model as an ArcMap add-on.
- Evaluate various data reduction effects on root mean square error (RMSE) values.

Data

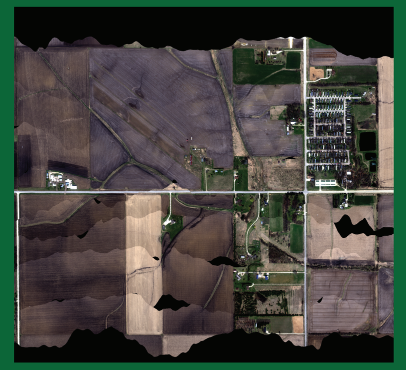
Figure 1: AISA Dual true color image mosaic of Cedar Falls and surrounding Black Hawk County, Iowa.

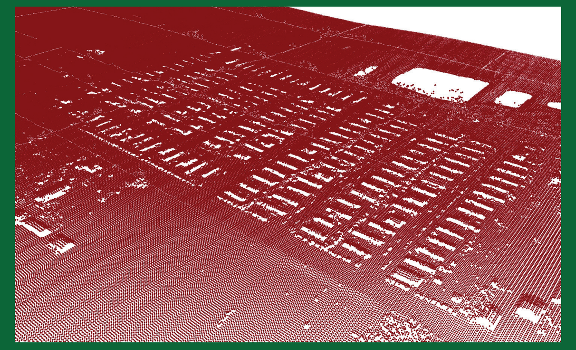
Figure 2: LiDAR shapefile of the last return data set showing the residential area of the study area.

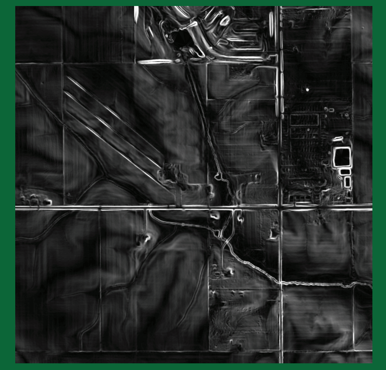
Figure 3: Slope raster of the study area obtained from the Iowa DNR at a three meter spatial resolution.

Hyperspectral

- An AISA Dual hyperspectral image covering Cedar Falls and surrounding Black Hawk County, Iowa taken on April 22, 2009 was used. The image contains 359 bands with wavelengths from 0.4 to 2.5 micrometers and has a spatial resolution of one meter.

LiDAR

- The one meter LiDAR data in the .las format was obtained from the Iowa LiDAR mapping project that has a spatial resolution of.

Slope

- Slope raster file obtained from the Iowa DNR's NRGIS library with a spatial resolution of three meters.

Methodology

- The methodology provided in Figure 4 was performed specifying the agricultural, grass, and grass dormant land covers for reduction.
- The land cover types were chosen because they correspond to less complex terrain types.
- ENVI 4.8 software was used for the hyperspectral land cover classification.
- The landscaped-based reduction interface was implemented in ArcMap 10.1.
- All RMSE values were calculated using the raster calculator function on ArcMap 10.1 and were computed from the all returns raster created by IDW interpolation.

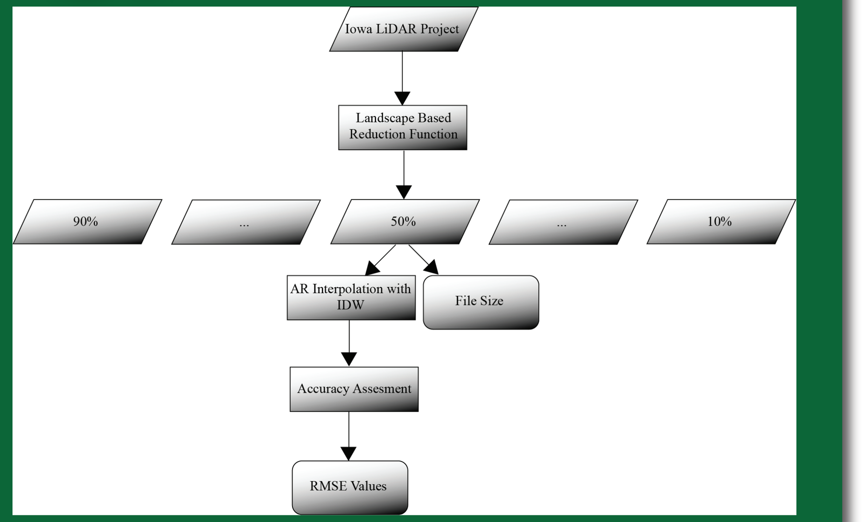

Figure 4: Flowchart that shows the methodology that was followed in the study.

Results

Hyperspectral Landcover Classification

- Land cover classification was performed with ENVI 4.8 to produce ten land cover classes of roofs, roads, coniferous trees, deciduous trees, agricultural land, grass, grass dormant, water ways, water, and no data.
- Problems arose due to the non-overlapping and narrow flight paths of the AISA Dual image, which lead to 18.24% of the image being classified as no data.
- The early spring flight date of the image lead to a lack of agri cultural vegetation classification, but allowed for deciduous and coniferous trees to be easily distinguished and roofs to be free of leaf cover.

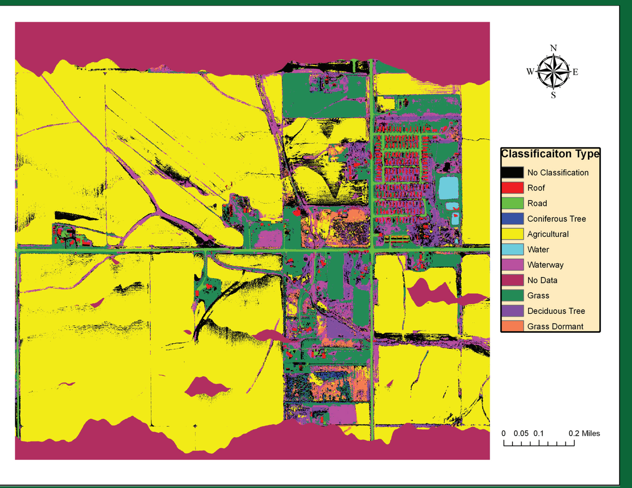
Figure 5: Hyperspectral landcover classification of the study area.

Table 1: Table showing the number of points in each land cover classification shown in Figure 5.

Classification	Number of Points	Percent of Total Points (%)
No Classification	299374	6.93
Roof	44245	1.02
Road	82717	1.92
Coniferous Tree	5493	0.13
Agricultural	2322585	53.80
Water	12376	0.29
Waterway	229654	5.32
No Data	787501	18.24
Grass	385991	8.94
Deciduous Tree	90494	2.10
Grass Dormant	56580	1.31

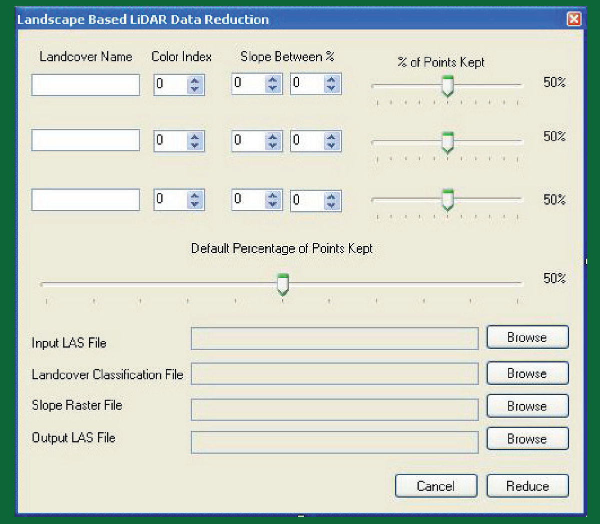
Figure 6: User interface programmed in C# that allows a user to input parameters for landscape-based LiDAR data reduction.

ArcMap User Interface

- Allows a user to enter up to three different landscapes for reduction based on a slope map and the classified land cover image.
- The interface was programmed in C# using Microsoft's Visual C# 2010 Express.

Results

Accuracy Assessment and File Size

- RMSE values for all levels of reduction are around 2 meters.
- File sizes range from 120 megabytes to 110 megabytes and decrease linearly.

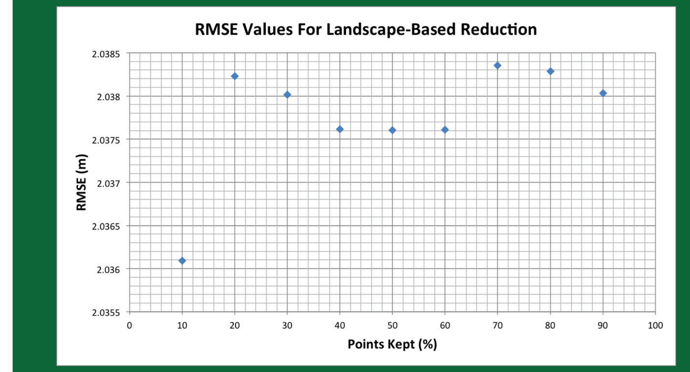

Figure 7: Graph showing the RMSE values for the all returns raster image of the different levels of reduction.

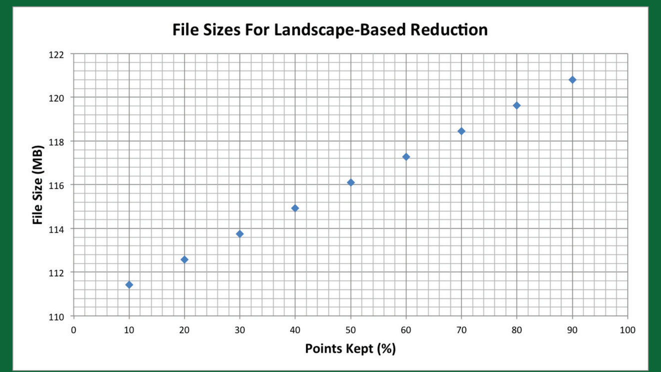

Figure 8: Graph showing the file size values for the .las files of the different levels of reduction.

Table 2: Table showing the RMSE values for the different levels of reduction.

% of Points	RMSE (m)
90	2.03803
80	2.03829
70	2.03835
60	2.03761
50	2.03760
40	2.03762
30	2.03801
20	2.03823
10	2.03609

Table 3: Table showing the file size values for the the different levels of reduction.

% of Points	File Size (MB)
90	120.804
80	119.635
70	118.458
60	117.28
50	116.104
40	114.932
30	113.757
20	112.583
10	111.42

Conclusions

Hyperspectral Landcover Classification

- Hyperspectral land cover classification algorithms produced a detailed classification image quickly and easily.

ArcMap User Interface

- A user interface that facilitated the input of reduction parameters to the landscape-based reduction function was programmed in C# for a toolbar in ArcMap.

Accuracy Assessment and File Size

- RMSE values for all levels of reduction vary only by a hundredth of a meter despite having a reduction in size of up to 10 megabytes.
- With an decrease in file size of up to 10 megabytes the random keeping of points used in this method shows promising results.
- In the future a more advanced method of selecting what points are kept in each region can be implemented into the landscape-based reduction method.
- Although the .las file sizes for landscape-based reduction appear to decrease linearly, the RMSE values vary in a different pattern.

Acknowledgements

Jonathan Voss furnished both the executable file and its source code that made this implementation of landscape-based reduction succeed. I would like to thank Dr. Ramanathan Sugumaran, Dr. Andrey Petrov, and Dr. Bingqing Liang for providing me with much support and guidance picking my topic and completing this project. Graduate mentors Matthew Cooney, Andrey Kuskin, and Tesfay Russell also gave me much technical assistance. Finally, I would like to thank Alison Tenhulzen for collaborating on the pre-processing of the hyperspectral image and Dr. Bradley Cramer for his assistance on my poster.