Accuracy Assessment of LIDAR Data

By:

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Abstract

The removal of the Marmot Dam was an attempt made by Portland General Electric (PGE) to restore the Sandy River, OR to its natural state. After the removal, the Sandy River underwent numerous changes. Some of the various changes occurred and are occurring in the elevation of the river's banks, bars, islands, etc. To observe these elevation changes, scientists have collected Light Detection and Ranging (LIDAR) data for the years 2006-2008. When the scientists collected this data, they did it with the expectation that the data was as accurate as possible. However, how well do LIDAR data's yearly measured elevations of unmoving structures compare? It is imperative to know the amount of height differentiation that is due to technique and how much is genuine change of the Earth's surface. This project requires the use of ArcGIS to make these comparisons. The end result of this project will determine possible sources of uncertainty in LIDAR data and any uncertainty to the foot in the Revenue Bridge area LIDAR data of the Sandy River.

Introduction

The United States is currently home to over 75,000 dams, each having a purpose of its own. However, the effects dams have on the environment surrounding them are consistent among them all. Dams alter the natural patterns of water, energy, sediment, wildlife, and nutrient flow along the rivers in which they are built (Beyer 2002). Because about 85% of these United States dams will have outlived their design or purpose by the year of 2020, dam removal and river restoration have become major issues (Doyle 2003).

When considering dam removal and river restoration, many factors must be taken into account. Various factors include cost, engineering, legal factors, etc (Hart 2002). Portland

General Electric (PGE) was faced with each of these factors as they considered the removal of the Marmot Dam which was located along the Sandy River in Oregon.

The Marmot Dam stood for approximately 97 years. The 47-foot dam was built on the Sandy River in 1913 with the initial purpose of generating hydroelectricity for the city of Portland, Oregon. PGE designed a system of canals, tunnels, box flumes, and diversion dams to feed a power house located just below Rosslyn Lake. This system worked well until rising environmental cost made the upkeep of the dam useless ("Marmot Dam" 2009). In 1999, the dam's removal was announced by PGE. It was not until the year 2007, however, that the removal took place ("Sandy River" 2008).

After the Marmot Dam's removal, scientist and researchers have closely watched the Sandy River's progression toward restoration. Approximately 750,000 cubic meters of sediment piled behind the dam before its removal. It is important for researchers to observe the distribution or lack of distribution of this sediment and other changes that are taking place on the river. One such person is graduate student Chuck Podolak of Johns Hopkins University. Podolak has conducted a three year long study along the Sandy River with the accompaniment of five interns each year.

Background

This individual project is designed to determine the accuracy of Light Detection and Ranging (LIDAR) data. LIDAR is a remote sensing system used to collect topographic data. This data is collected with aircraft-mounted lasers which have the capability of recording elevation measurements at a rate of 2,000 to 5,000 pulses per second. As the airborne aircraft lets off high frequency laser beams towards the Earth's surface, the LIDAR sensor records the time elapsing between the release of the laser beam and the return of the reflected laser to the aircraft, thus, creating LIDAR data ("About LIDAR Data" 2007).

Figure 1: Laser -Scanning

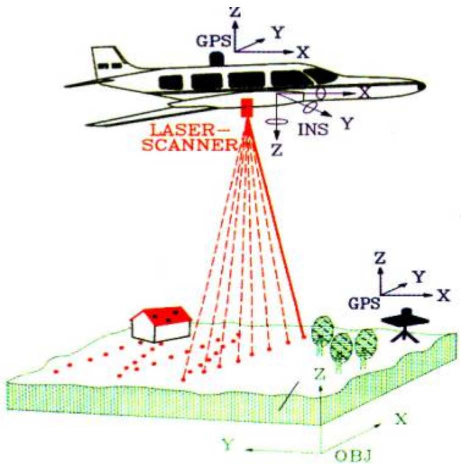


Figure 2: Reach B1 LIDAR Data 2008

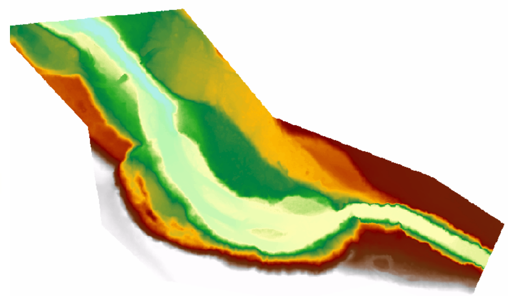


Figure 1: Depiction of LIDAR data being captured.

Figure 2: Example of a Sandy River LIDAR data DEM

Errors in LIDAR data are due to a number of possibilities. For example when dealing with bedrock, the physical position of the bedrock will not change; however, pieces of bedrock can chip off causing elevation changes. Other errors created when collecting LIDAR data can be due to range errors, position errors, and orientation errors (Flood 2001). Range errors are the errors that occur as a result of atmospheric distortion. Position errors are errors due to GPS uncertainty, and orientation errors are errors that relate to the positioning of the aircraft-mounted laser (Flood 2001). Reasoning for the elevation change in stationary objects along the Sandy River could be due to any of these errors.

Methodology

Using LIDAR data for the years 2006-2008 from the provided Revenue Bridge area (Reach B1), the process of determining LIDAR's accuracy began by visually comparing digital elevation models (DEMs) in ArcGIS.. The areas in Reach B1 where unmoving objects such as homes, roads, and bedrock were positioned should have showed no change between each year's models. Predominantly, this was true. However, vision is not an accurate judge and can vary from person to person. Thus, the DEMs were compared with the "Identify" tool in ArcGIS. This tool allows one to find elevation at any selected location on a DEM or any selected location on multiple DEMs. For example, at a building's coordinates, 7,757,011.774/ 639,277.197 feet, the elevation for the year of 2006 is 524.88 feet, the elevation for the year of 2007 is 524.80 feet, and the elevation for the year of 2008 is 524.90 feet. Because differentiation occurred in the elevation of this home which should have been the same throughout the three years, it can be determined that the LIDAR data of Reach B1 is not 100% accurate.

Continuing this method, the elevations from year to year of 30 various stationary objects in Reach B1were determined. This data went into a spread sheet in Microsoft's Excel. When this was completed, the elevations from the year of 2006 were subtracted from elevations of the year of 2007 to determine any differences in the elevations that should be the same. These differences were the amounts of error between each point. The same was done with the years 2007 and 2008.

When referring to the location above, for example, the difference or vertical error between the years 2006 and 2007 is 0.08 feet and the vertical error between the years 2007 and 2008 is 0.10 feet. At the completion of this process, the differences between the years 2006 and 2007 were averaged and the differences between the years 2007 and 2008 were averaged. These results showed that the average difference between the years 2006 and 2007 is 0.94 feet and the average difference between the years 2007 and 2008 is 0.75 feet. For the individual categories of bedrock, buildings, and roads between the years 2006 and 2007, bedrock has an average difference of 5.97 feet, buildings have an average difference of 0.60 feet, and roads have an average difference of 0.55 feet. For the individual categories of bedrock, buildings, and roads between the years 2007 and 2008, bedrock has an average difference of 7.40 feet, buildings have an average difference of 0.27 feet, and roads have an average difference of 0.28 feet.

Results

According to the analyzed Light Detection and Ranging (LIDAR) data in Reach B1, the error that exists between the years 2006 and 2007 is on average 0.94 vertical feet. The error that exists between the years 2007 and 2008 is on average 0.75 vertical feet. For the categories of bedrock, buildings, and roads between the years 2006 and 2007, bedrock has an average difference of 5.97 feet, buildings have an average difference of 0.60 feet, and roads have an average difference of 0.55 feet. For the categories of bedrock, buildings, and roads between the years 2007 and 2008, bedrock has an average difference of 7.40 feet, buildings have an average difference of 0.27 feet, and roads have an average difference of 0.28 feet.

Latitude/ Longitude	2008 (ft)	2007 (ft)	2006 (ft)	Category	Dif. b/t 2008 & 2007	Dif. b/t 2007& 2006
7,756,464.824 639,615.554	431.594513	445.890015	434.160004	Bedrock	14.295502	11.730011
7,756,059.619 639,948.617	428.969818	428.470001	428.679993	Bedrock	0.499817	0.209992
7,755,314.819 639,867.631	507.119476	506.950012	506.140015	Building	0.169464	0.809997
7,755,590.332 639,706.243	509.087952	508.959991	508.609985	Building	0.127961	0.350006
7,756,081.414 639,781.173	466.797913	466.500000	466.540009	Building	0.297913	0.040009
7,756,147.122 639,712.007	468.077423	468.029999	467.549988	Building	0.047424	0.480011
7,756,543.653 639,758.659	498.490845	498.589996	497.429993	Building	0.099151	1.160003
7,756,452.696 640,042.442	496.391113	496.369995	496.420013	Building	0.021118	0.050018
7,757,169.432 639,781.701	521.292664	521.179993	520.219971	Building	0.112671	0.960022
7,757,011.774 639,277.197	524.901611	524.799988	524.880005	Building	0.101623	0.080017
7,756,484.228 639,275.984	472.342529	472.440002	471.859985	Building	0.097473	0.580017

7,756,560.631 638,958.243	488.287415	488.130005	486.959991	Building	0.157410	1.170014
7,757,935.890 638,866.074	537.959351	538.150024	537.820007	Building	0.190673	0.330017
7,757,330.728 638,612.609	499.803162	500.640015	500.420013	Building	0.836853	0.220002
7,758,015.932 638,326.400	504.429138	502.679993	503.769989	Building	1.749145	1.089996
7,757,688.489 638,266.975	501.410797	501.070007	500.609985	Building	0.340790	0.460022
7,756,225.912 637,996.532	680.118164	680.130005	681.229980	Building	0.011841	1.099975
7,758,435.544 638,360.357	539.206055	538.750000	539.960022	Building	0.456055	1.210022
7,758,528.926 638,337.315	542.388489	542.400024	542.239990	Building	0.011535	0.160034
7,755,720.926 639,384.838	554.855652	554.820007	554.320007	Building	0.035645	0.500000
7,755,889.980 639,484.577	520.275635	520.140015	519.419983	Road	0.135620	0.720032
7,756,988.732 639,702.872	517.749329	517.859985	517.530029	Road	0.110656	0.329956
7,757,458.067 639,541.576	532.578735	533.159973	532.809998	Road	0.581238	0.349975
7,757,466.556 639,539.151	533.497375	533.820007	533.289978	Road	0.322632	0.530029
7,758,000.166 638,850.308	539.041992	539.349976	538.559998	Road	0.307984	0.789978
7,755,373.639 639,921.037	501.115509	501.440002	500.760010	Road	0.324493	0.679992
7,755,818.341 639,616.362	516.601074	516.900024	516.489990	Road	0.298950	0.410034
7,756,053.772 639,557.889	495.734955	496.079987	495.410004	Road	0.345032	0.669983
7,756,193.347 639,347.318	491.305786	491.529999	490.820007	Road	0.224213	0.709992
7,757,216.552 639,621.982	524.803162	524.940002	524.640015	Road	0.136840	0.299987
Overall Mean (ft)	511.540921	512.005668	511.318332		0.748257	0.939338
Bedrock Dif. Mean (ft)					7.397659	5.970002
Building Dif. Mean (ft)					0.270264	0.597232
Road Dif. Mean (ft)					0.278766	0.548996
Mean Dif. Excluding Bedrock (ft)					0.273300	0.580005

Using rasters, which are representations of elevation changes, the elevation changes along the Sandy River in Reach B1 can be observed. The raster representing change between years 2006 and 2007 is shown in Figure 3, and the raster representing change between years 2007 and 2008 is shown in Figure 4.

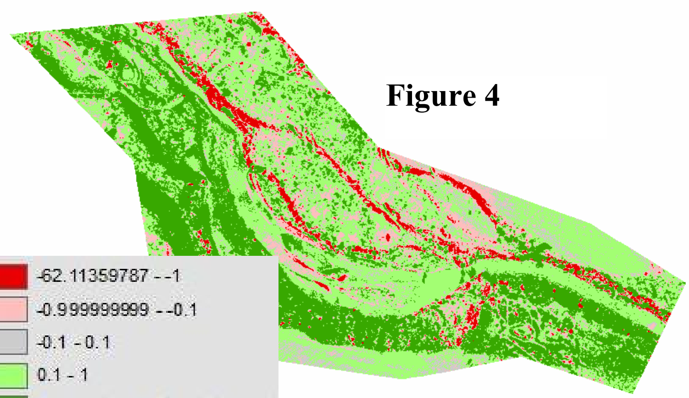
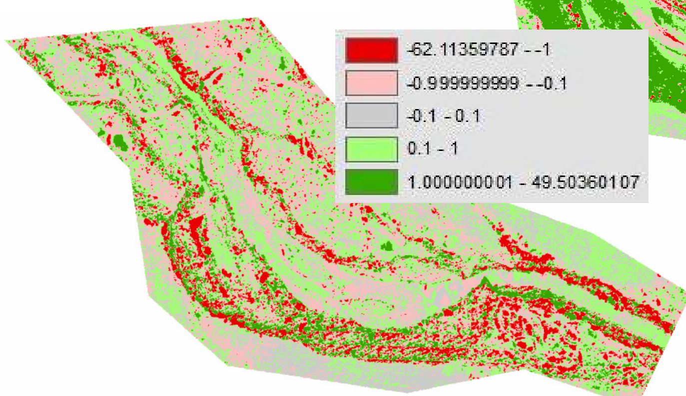


Figure 4

Figure 3



Summary

According to the LIDAR data of Reach B1, it can be said that between the years of 2007 and 2008 the Sandy River's surroundings saw much more elevation changes than the elevation changes it experienced during the years of 2006 and 2007. Most of this change being an increase in elevation. Considering the Marmot Dam's removal took place in the year of 2007, it can be expected that more change would occur after that removal.

Furthermore, the results of this Light Detection and Ranging data project have shown that LIDAR data may consist of a vertical error ranging from approximately 0.27-1.0 feet. When considering that along the Sandy River there are numerous places that had elevation change within this range, one could say that LIDAR is not appropriate for this overall project. However, there are areas along the Sandy that exceed elevation changes in this interval. Yet when considering other data collection options, there are few that would give significantly better results. Because of its technology and new developments, LIDAR is one of the most accurate elevation detectors.

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