Terrain Mapping Using LiDAR Technology

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Introduction

- Scientists often need to record information about a landscape in order to understand an ecosystem and estimate its conditions and characteristics.
- LiDAR, or light detection ranging, is a remote sensing method that can be used to map densely populated areas, thick forests, rugged mountains, and all sorts of surfaces and terrains.
- In a LiDAR, the photons that make up the lasers' light travel towards the ground, reflect off of surfaces, and return to the sensor where they are recorded in order to calculate the distance traveled.
- The distribution of energy that returns to the sensor creates a 3D representation of its surroundings with an accuracy of ± 3 cm. These point clouds contain various characteristics that depict objects such as cars, trees, and buildings.

Research Objectives

- Set-up a Velodyne VLP-16 Puck™ LiDAR sensor to collect point cloud data.
- Validate point cloud parameter estimates to in-situ measures to verify the accuracy of the system.
- Develop an embedded computer system that remotely collects point cloud data from the Velodyne VLP-16 Puck™.
- Implement data extraction algorithms to the data collected from the VLP-16.

Rationale

- Create a mobile data collector that can be used by emergency response teams on environments that have been severely affected by natural disasters such as hurricanes, snow storms, flash floods and landslides.
- Obtain access to said information in a rapid and low-cost manner with the purpose of observing the changes produced in the environment with more precision.

Methodology

- The Velodyne VLP-16 was initialized, deployed, and used to capture and process point cloud data from UPRM's Department of Civil Engineering and Surveying Lab.
- Point cloud data packet files were compared to on site measures in order to verify the accuracy of the system.
- A Raspberry Pi 3 Model B running Ubuntu 18.04.2 LTS and ROS Velodyne libraries was programmed to read and store LiDAR data.
- A wireless local area network (WLAN) was established to remotely execute scripts and monitor data collection in real time.
- Collected data was then migrated to an Alienware Aurora running a GeForce GTX 1080 Graphics Card to co-register the scans into a continuous point cloud.
- The data clouds were then processed and analyzed in order to normalize and classify individual points using Veloview.

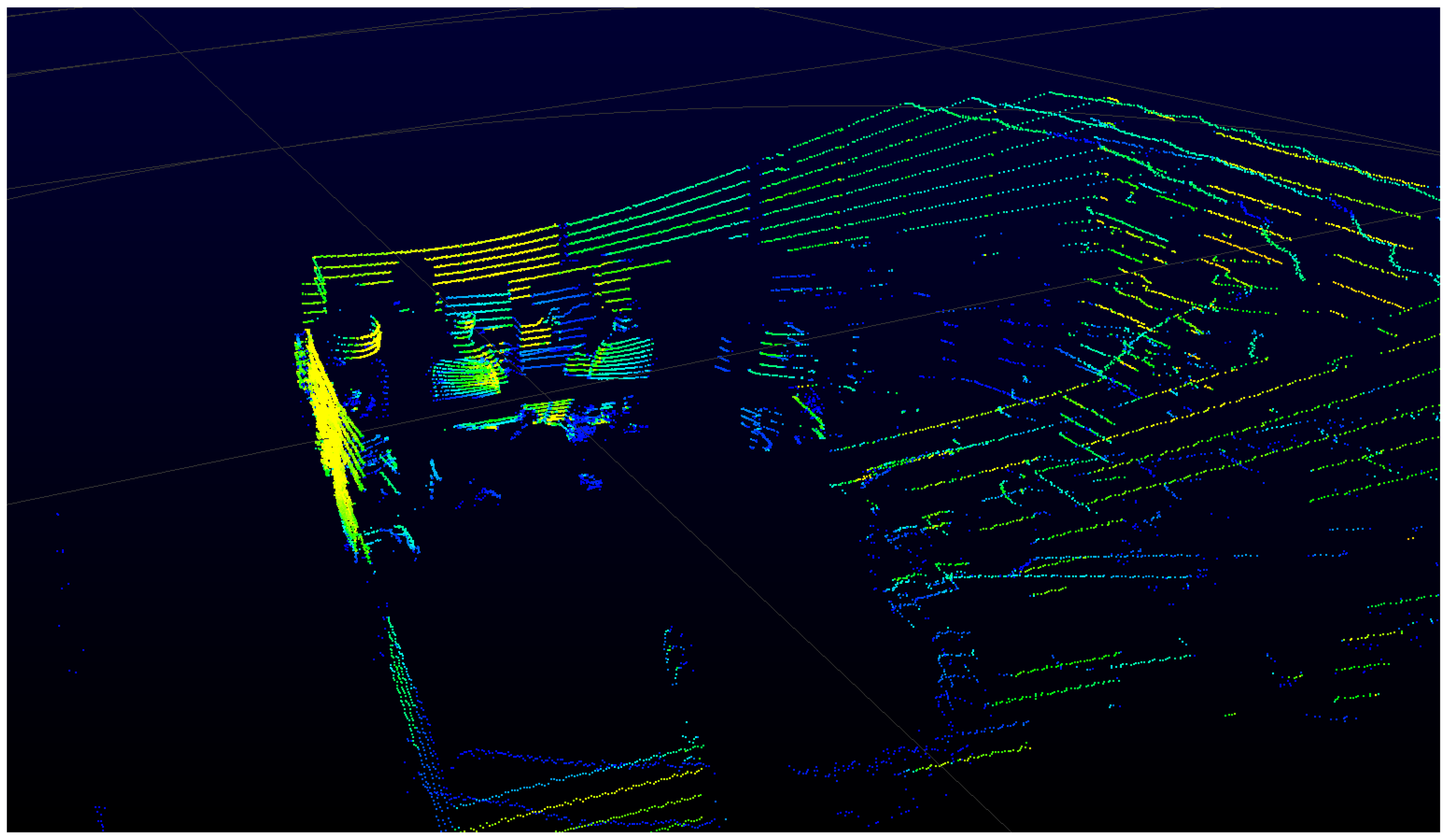

Figure 1: UPRM's Department of Civil Engineering and Surveying Lab Point Cloud Data

Results

- The height of the Lab was determined to be 8.25 ft. using a tape measurer.
- Using the top and bottom Z coordinate points registered in the 390th frame of the point cloud data captured by the LiDAR, the height of the room was calculated to be 8.235 ft.

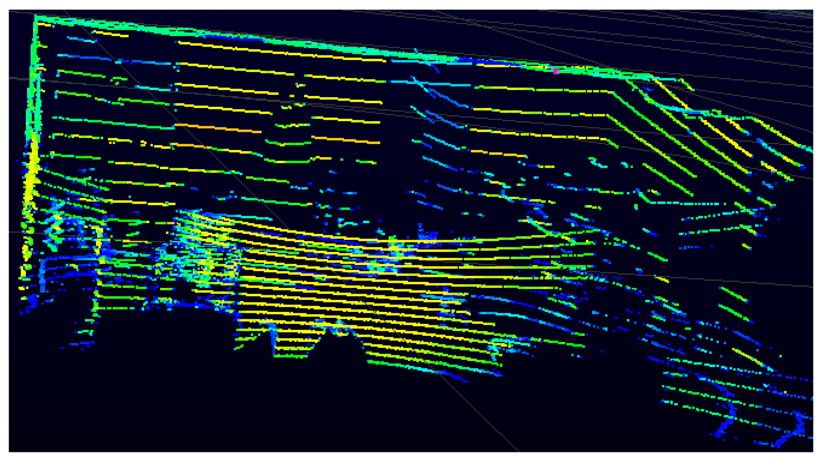

Figure 2: Surveying Labs' Top Z Point Cloud Coordinate (In Magenta)

	Point ID	X	Y	Ẑ	adjustedtime	azimuth	distance_m	intensity	laser_id	timestamp	vertical_angle
87	3114	3.06	3.54	1.25	426952065.00	4086	4.84	57	15	426952065	15.00
88	3156	3.09	3.50	1.25	426952231.00	4145	4.84	58	15	426952231	15.00
89	2642	2.64	3.85	1.25	426950294.00	3446	4.84	1	15	426950294	15.00
90	2696	2.70	3.82	1.25	426950516.00	3525	4.84	2	15	426950516	15.00
91	3099	3.04	3.55	1.25	426952009.00	4066	4.84	59	15	426952009	15.00
92	2583	2.59	3.89	1.25	426950073.00	3365	4.83	1	15	426950073	15.00
93	2598	2.60	3.88	1.25	426950128.00	3386	4.83	1	15	426950128	15.00
94	2734	2.74	3.78	1.25	426950682.00	3587	4.83	31	15	426950682	15.00
95	3085	3.03	3.55	1.25	426951954.00	4045	4.83	57	15	426951954	15.00
96	3938	4.27	3.33	1.25	426955156.00	5203	5.55	71	13	426955156	13.00
97	2656	2.65	3.83	1.25	426950351.00	3466	4.83	1	15	426950351	15.00
98	3071	3.01	3.56	1.25	426951899.00	4025	4.83	54	15	426951899	15.00

Table 1: Surveying Labs' Top Z coordinate Values (Highlighted)

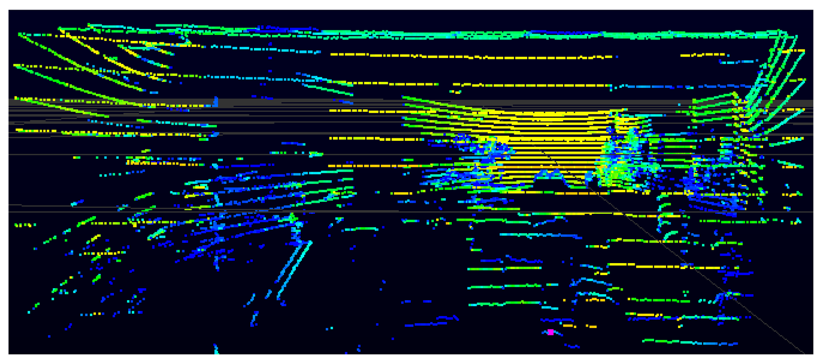

Figure 3: Surveying Labs' Bottom Z Point Cloud Coordinate (In Magenta)

	Point ID	X	Y	Ž	adjustedtime	azimuth	distance_m	intensity	laser_id	timestamp	vertical_angle
75	24284	-1.27	4.57	-1.27	427036522.00	34444	4.91	4	0	427036522	-15.00
76	24299	-1.26	4.57	-1.27	427036577.00	34463	4.91	3	0	427036577	-15.00
77	3031	4.18	5.02	-1.27	426951763.00	3977	6.65	0	4	426951763	-11.00
78	205	0.26	5.49	-1.27	426941528.00	270	5.64	9	2	426941528	-13.00
79	155	0.17	4.72	-1.27	426941358.00	207	4.89	1	0	426941358	-15.00
80	173	0.22	5.48	-1.27	426941418.00	229	5.63	19	2	426941418	-13.00
81	109	0.14	5.48	-1.27	426941196.00	149	5.62	21	2	426941196	-13.00
82	2255	2.70	4.77	-1.27	426948937.00	2954	5.62	9	2	426948937	-13.00
83	24270	-1.28	4.54	-1.26	427036467.00	34423	4.89	3	0	427036467	-15.00
84	141	0.18	5.47	-1.26	426941307.00	188	5.62	21	2	426941307	-13.00
85	157	0.20	5.47	-1.26	426941362.00	209	5.62	21	2	426941362	-13.00

Table 2: Surveying Labs' Bottom Z coordinate Values (Highlighted)

Conclusions

- The Velodyne VLP-16 Puck™ was used to map the inside of the University of Puerto Rico - Mayagüez's Department of Civil Engineering and Surveying Lab. In order to validate the point cloud data captured by the LiDAR, the lab was thoroughly measured using traditional measuring techniques.
- Using the data collected by both the terrestrial configuration and the embedded computer system, the VLP-16 Puck's™ range accuracy was proven to be within the advertised value of ± 3 cm.

Future Work

- Obtain a more accurate point cloud representation of a terrain, an unmanned aerial vehicle (UAV), more specifically the DJI Matrice 100, has been considered in order to run aerial scans of an area.
- In order to carry out said objective, a 3D printed mount containing the embedded computer system and the Velodyne VLP-16 LiDAR was designed to fit as the DJI M100's payload.

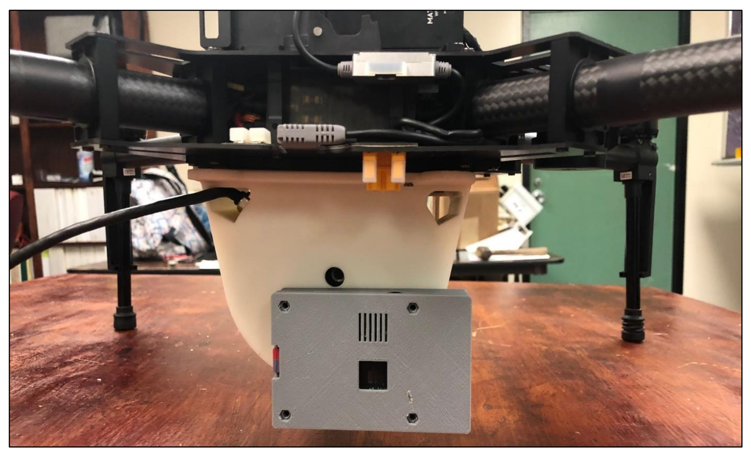

Figure 4: 3D printed mount installed as the DJI M100's Payload

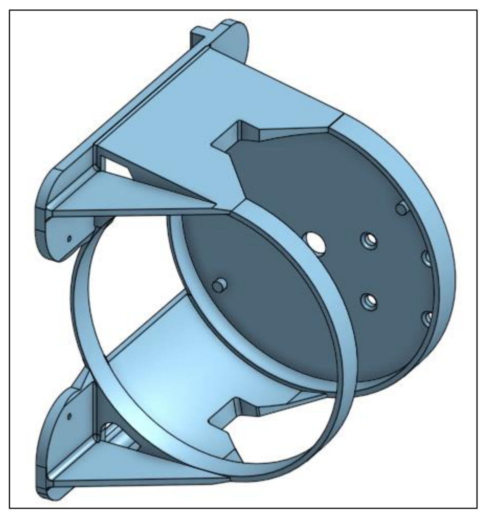

Figure 5: 3D mount in Onshape

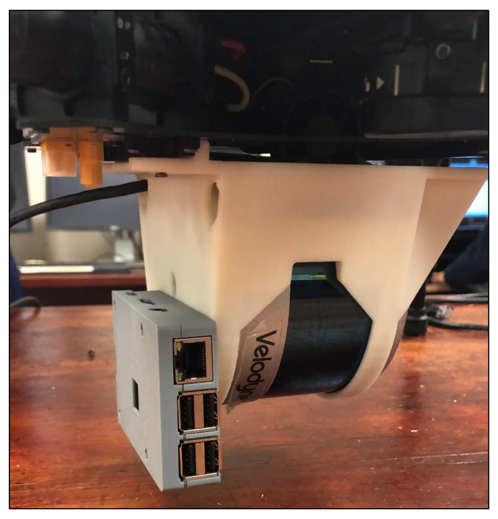

Figure 6: Right View of the 3D printed mount

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ACKNOWLEDGEMENT: This study is supported and monitored by The National Oceanic and Atmospheric Administration – Cooperative Science Center for Earth System Sciences and Remote Sensing Technologies under the Cooperative Agreement Grant #: NA16SEC4810008. The author(s) would like to thank The City College of New York and NOAA Office of Education, Educational Partnership Program with Minority Serving Institutions (EPP/MSI) for support for Sebastián Hernández & Adriana M. Muñoz. The statements contained within the poster are not the opinions of the funding agency or the U.S. government, but reflect the author's opinions.