Demo: Understanding the Effects of Paint Colors on LiDAR Point Cloud Intensities

Shaik Sabiha, Keyan Guo, Foad Hajiaghajani, Chunming Qiao, Hongxin Hu, Ziming Zhao
University at Buffalo
{shaiksab, keyanguo, foadhaji, qiao, hongxinh, zimingzh}@buffalo.edu

***Abstract*—Light Detection And Ranging (LiDAR) is a critical component in autonomous vehicles that aid in object detection. It generates point clouds by projecting light rays to its surroundings. This demo studies the effect of paint colors on autonomous driving perception. The experiment results show different colors do affect LiDAR sensor's point cloud intensity.**

I. Introduction

The LiDAR sensor plays a crucial role in detecting obstacles in a driving environment, as the accuracy of its output directly affects the safety of vehicles and pedestrians. Even if it is suspected that different paint colors on objects may influence the detection of the LiDAR sensor [1]–[4], the myth is neither confirmed nor denied in any academic study. This demo reports the sensed results from an Ouster OS1 mid-range high-resolution imaging LiDAR [5] mounted on an autonomous car under different scenarios. The results confirm that the sensed intensities of the same object with different paint colors differ.

Experiment Setup. We used two objects i) an orange PVC traffic cone with a reflective strip (28 inches tall), ii) a brown cardboard sheet (12x24 inches) and three commonly used automotive paints [6] i) jet black automotive paint [7], ii) blue metallic automotive paint [8], and iii) brilliant silver automotive paint [9] in the experiments. We placed the cardboard and traffic cone several feet away from the front of the autonomous vehicle, and we obtained the LiDAR output on either object with the original color and the three paint colors. The output of the LiDAR sensor is in the Point Cloud Data (PCD) format, where the non-zero intensity (range 1 - 256 for each point) of the reflected laser at each coordinate of the 3-dimensional space around the vehicle is recorded. We used the MATLAB LiDAR toolbox ground removal and crop feature to extract the 3D region of interest from the raw data.

II. Demonstration

Table I and Table II show the LiDAR output intensity statistics for the same cardboard and traffic cone with different paint colors, respectively. The cardboard was placed 20 feet away from the vehicle, and the cone was placed at 16 and 20 feet away for the experiments.

	Dis.	Average	Max	Min	Median	SD
Brown (296)	20	696.3	833	436	694	69.02
Metallic Blue (295)		983.2	1254	406	993	123.78
Jet Black (291)		605.15	1222	403	588	143.76

TABLE I: LiDAR output intensity statistics for the same cardboard with different colors. The board was placed 20 feet away from the vehicle. SD: Standard Deviation. Inside the parentheses are the number of points with non-zero intensity.

	Dis.	Average	Max	Min	Median	SD
Orange (296)	16	2030	4312	414	1630	1314.99
Brilliant Silver (291)		679.59	953	420	697.5	154.74
Metallic Blue (295)		635.09	844	429	654	117.88
Orange (46)	20	1727.07	4386	90	873.5	1668.13
Brilliant Silver (25)		548.36	1132	71	481	327.11
Metallic Blue (9)		114.89	130	103	112	9.32

TABLE II: LiDAR output intensity statistics for the same traffic cone with different colors.

As Table I shows, the number of cloud points with non-zero intensity decrease slightly from the original brown to the jet black. The lighter metallic blue has the highest average intensity among the three colors, whereas the jet black has the lowest average intensity.

As Table II shows, when the cone is 16 feet away color orange has the highest average intensity, followed by the brilliant silver and metallic blue. The standard deviation of the original orange corn is high because of the presence of a reflective strip on it. When the cone is placed 20 feet away, the average intensity of metallic blue decreases dramatically from the 16 feet experiment. The number of non-zero points for metallic blue also decreased faster than the color orange (from 295 to 9).

Take-aways. Our experiments confirm that the paint colors can influence the LiDAR intensity readings. On the same object, colors with lower value (lightness) result in lower average intensity compared to more reflective colors with higher value. It is possible to intentionally paint objects, even a car, with a less detectable color to fool the LiDAR system and danger the vehicles and pedestrians on the road. In the future, we plan to carry out experiments with real vehicles and implement using additional colors, such as VantaBlack 2.0 and Chrome Silver that are known for their high light-absorbing properties, objects, and different experiment setups. We also plan to test at different times during the day with different sunlight conditions. And we will study and analyze other data that LiDAR can sense, such as reflectivity.

Workshop on Automotive and Autonomous Vehicle Security (AutoSec) 2022
24 April 2022, San Diego, CA, USA
ISBN 1-891562-75-4
https://dx.doi.org/10.14722/autosec.2022.23039
www.ndss-symposium.org

REFERENCES

[1] Jamie L. LaReau. You can have that car in any color you want, as long as it's white. https://www.freep.com/story/money/cars/2018/08/21/white-lidar-self-driving-technology/1042114002/.

[2] Melissa Steinken. How your paint department affects self-driving technology. https://www.adaptautomotive.com/articles/19-how-your-paint-department-affects-self-driving-technology.

[3] Christopher M. Seubert. The future of coatings in a world of autonomous vehicles. https://www.paint.org/coatingstech-magazine/articles/future-coatings-world-autonomous-vehicles/.

[4] Nick Holt. Detection needs reflection: paintshop's crucial role in autonomous mobility. https://www.automotivemanufacturingsolutions.com/paintshop/detection-needs-reflection-paintshops-crucial-role-in-autonomous-mobility/39630.article.

[5] Inc. Ouster. Os1 mid-range high-resolution imaging lidar. https://www.dtc-solutions.de/fileadmin/uploads/user_upload/Downloads/OS1-lidar-sensor-datasheet.pdf.

[6] Axalta Coating Systems. Global automotive 2020 color popularity report. https://www.axalta.com/content/dam/New%20Axalta%20Corporate%20Website/Documents/Brochures/axalta-2020-global-automotive-color-popularity-report.pdf.

[7] Inc. Amazon. Dupli-color bsp200 jet black paint shop finish system - 32 fl oz, step 2,single. https://www.amazon.com/Dupli-Color-BSP200-Black-Finish-System/dp/B0029818Q6/ref=sr_1_9?dchild=1.

[8] Inc. Amazon. Dupli-color bsp204 deep blue metallic paint shop finish system. https://www.amazon.com/Dupli-Color-BSP204-Metallic-Finish-System/dp/B002988GWU?th=1.

[9] Inc. Amazon. Dupli-color bsp202 brilliant silver metallic paint shop finish system. https://www.amazon.com/Dupli-Color-BSP202-Brilliant-Silver-Metallic/dp/B00298AKKG?th=1.