Generating Decimated LiDAR Data for Autonomous Vehicles Using Interpolation Approach

Imran Ashraf*, Soojung Hur, Yongwan Park

Information and Communication Engineering, Yeungnam University, Korea.

imranashraf@ynu.ac.kr, sjheo@ynu.ac.kr, ywpark@yu.ac.kr

Abstract

Light Detection And Ranging (LIDAR) has become the most widely used technology for intelligent vehicles in the recent past. LIDAR system captures data not only in normal conditions, but also during rain and snow with increased accuracy and precision. Intensity images generated from reflecting of laser beams are further used for feature analysis, distinct object analysis and data fusion. Interpolation techniques are used for two purposes: to generate unknown points where cloud point is very thin or no points at all and adding more data to cloud point to get more detailed intensity image. Henceforth, LIDAR data density and interpolation methods are of chief interests to produce intensity images. This paper investigates interpolation methods including Natural Neighbor, Trilinear and Nearest Neighbor for their effectiveness to generate the intensity image. Correlation analysis and Root Mean Squared Error (RMSE) show that Natural Neighbor achieves highest correlation of 0.9420 with actual intensity image and has lowest RMSE.

Ⅰ. Introduction

Light Detection And Ranging (LiDAR) has become intensively used technology for intelligent vehicles in the recent decade. Besides providing data for normal weather, the less limitation of weather like rain and snow and time of day makes it more suitable to capture 3D surface information than other sensors [1]. Owing to LIDAR data capture speed and precision, it has become established tool for many areas of intelligent vehicles like road detection [2], curb detection, obstacle detection [3], etc.

LIDAR data is very important, yet processing large cloud point is computationally complex and time consuming. Instead a sparse cloud point is taken and interpolation techniques can be used to generate intensity images. The objective of this study is to investigate the relationship between raw LIDAR data, decimation and various interpolation techniques

Ⅱ. Methods

Interpolation is a statistical technique capable of potentially generating the unknown points between known points. It is used to produce intermediate unknown values of independent variable for spatial data

Natural neighbor invented by Sibson is a well-known technique for spatial interpolation. Invented by Robin Sibson, it uses Voronoi and Delaunay diagrams of a discrete set of spatial points [4]. In order to interpolate a value, it applies weight to closest points based on their proportionate areas. General equation used for natural neighbor is

$$G(x,y) = \sum_{i=1}^{n} w_i f(x_i, y_i)$$

Where G(x,y) is the estimated value of natural neighbor at (x,y), n is the number of nearest neighbors

Linear interpolation (also called curve fitting) is a numerical analysis technique which uses linear polynomials to derive a straight line between the given known points

$$y = y_0 + (y_1 - y_0)\frac{x - x_0}{x_1 - x_0}$$

Since, LIDAR intensity images has 3D data so trilinear interpolation is used for the experiment.

Nearest neighbor method is widely used in many areas like image processing, machine learning etc. and has very simple methodology. It approximates the value of a point in space given the points neighboring that point.

III. Results

Data is collected using Velodyne HDL-64E mounted on the vehicle in the urban area of Gyeongsan, South Korea during afternoon time and for normal weather conditions. Raw data is processed using Matlab R2022b. To perform the experiment raw data is decimated at 10%, 25%, and 50% for point cloud.

In order to check the accuracy of interpolated points correlation analysis is performed. In addition, Root Mean Squared Errors (RMSE) and Mean Absolute Deviation (MAD) is calculated to check how closely the interpolated data fit the actual data points.

Table 1 shows the calculated coefficients for selected interpolation techniques. The highest correlation is achieved when we perform Natural Neighbor interpolation on data at 50% decimation.

Table 1. Correlation coefficient between generated and reference intensity data.

Technique	Decimation			
	10%	25%	35%	50%
Nearest Neighbor	0.7575	0.8114	0.8733	0.9158
Trilinear	0.8149	0.8833	0.9055	0.9380
Natural Neighbor	0.8250	0.8899	0.911	0.9421

Figures 1 and 2 show visuall illustration of error for interpolation techniques with respect to level of data decimation.

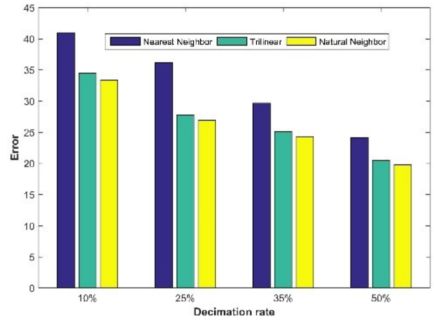

Figure 1. RMSE for intensity data.

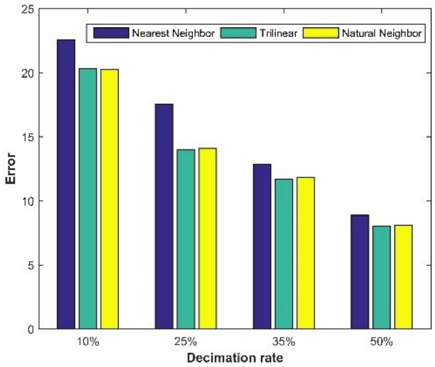

Figure 2. MAD for intensity data.

Figure 3 is the reference intensity image used to compare the interpolated values for the selected interpolation techniques. Figure 4 shows the result of Natural Neighbor interpolation technique at 50% decimation rate. After examining the results it is clear that only small difference in the image is perceptible.

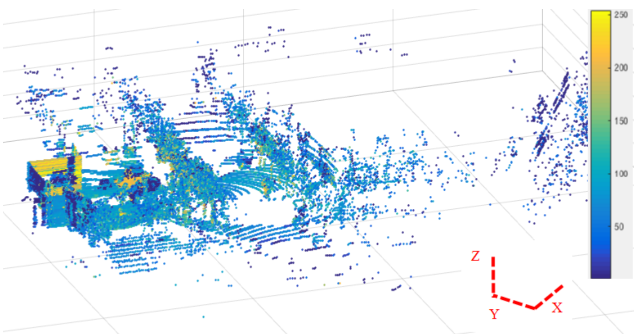

Figure 3. Reference LiDAR intensity data.

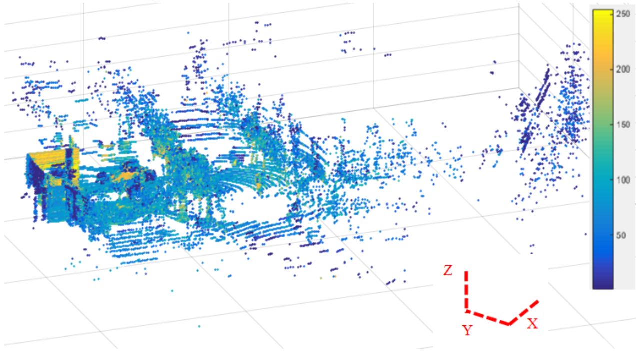

Figure 4. Generated intensity data with Natural Neighbor interpolation.

Most of the false points are generated in the range of 70 to 120 intensity due to which generated image gives greener look than the actual image. However, these values are only 6% as 94% of the interpolated points are correlated with actual intensity points.

IV. Conclusion

In this paper, raw LIDAR intensity data is processed using Matlab and decimation is performed at 10%, 25%, 35% and 50%. Three interpolation techniques including Nearest Neighbor, Trilinear and Natural Neighbor are applied to generate unknown intensity values at various coordinates. The suitability and accuracy of selected methods is evaluated by comparing interpolated intensity values with actual intensity points. Experiment shows that interpolation works quite satisfactory even at a low decimation rate.

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