The 2019 World Congress on
Advances in Nano, Bio, Robotics and Energy (ANBRE19)
Jeju Island, Korea, September 17 - 21, 2019

Accuracy improvement of Pulsed LiDAR using an Adaptive Radius Outlier Removal Algorithm

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ABSTRACT

The pulsed time-of-flight LiDAR (light detection and ranging) has been used in various fields for accurate 2D and 3D distance measurement at outdoor applications such as robotics and autonomous vehicles. Pulsed LiDAR are very sensitive to environmental factors such as snow and rain, which causes severe measurement errors. There are conventional methods such as multi-echo algorithm and radius outlier removal method used to overcome the problems. However, they have some disadvantages of complicated processing and performance limitation. In this work, time and distance-adaptive radius outlier removal method is proposed to improve the measurement performance against the environmental factors. Experimental results are presented to show the performance of the proposed method using a Pulsed LiDAR developed in a Sensor and Actuator lab. in GIST.

1. INTRODUCTION

The pulsed time-of-flight LiDAR (light detection and ranging) has been used in various fields for accurate 2D and 3D distance measurement at outdoor applications such as robotics and autonomous vehicles. (Weiss 2011, Levinson 2011, Ibisch 2013)

The pulsed LiDAR is very sensitive to environmental factors such as snow and rain, which causes severe measurement errors. (Kutila 2016) There are conventional methods such as last pulse method using multi-echo and radius outlier removal method used to overcome the problems. last pulse detection method is simple. The pulses reflected by snow or rain are appeared nearer than object. Using this phenomena, we can assume that the farthest pulse is object and rest of pulse is noise as shown Fig. 1. However, it is not easy to record all pulse and the last pulse is hard to detect because the intensity of the last pulse become low by previous reflection at rain or snow

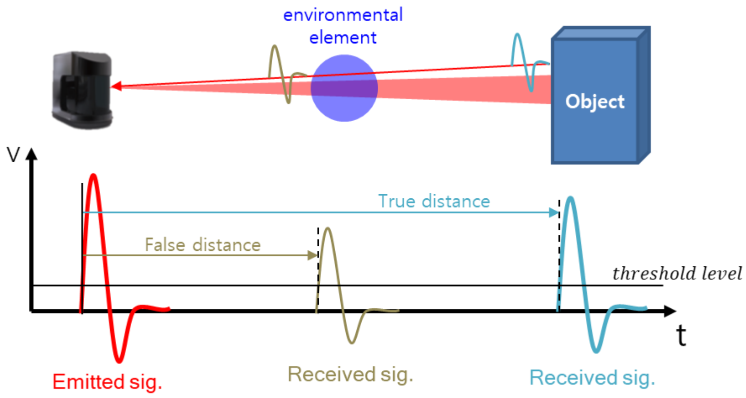


Fig. 1 The measurement error due to environmental effects

The radius outlier removal method decides noise or object using that how many neighbor point is existing as shown Fig.2. The radius outlier removal method is widely used for filtering point cloud data with its good filtering performance. (Schall 2015) However, filtering performance is low with LiDAR point cloud data. Because the spatial resolution of LiDAR point cloud data is varied by distance due to angular scanning mechanism of the LiDAR

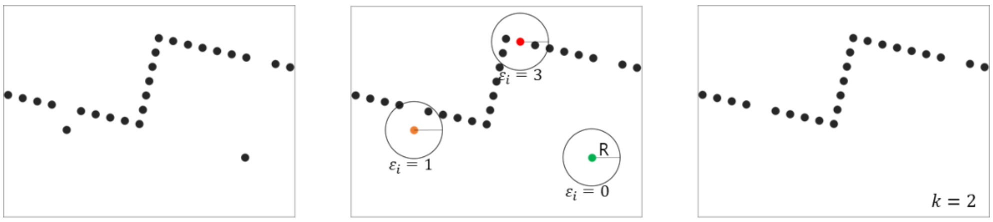


Fig. 2 radius outlier removal method

In this work, 3D LiDAR platform development for wide angle measurement is described in chapter 2. time and distance-adaptive radius outlier removal method is proposed to improve the measurement performance against the environmental factors in chapter 3. Experimental results are presented to show the performance of the proposed method using a Pulsed LiDAR developed in a Sensor and Actuator lab. in GIST.

2. 3D LIDAR PLATFORM DEVELOPMENT

The principle of the pulsed time-of-flight LiDAR (Light Detection and Ranging) is to measure distance by obtaining the time difference between emitted laser and reflected laser as shown Fig. 3. Distance is obtained using Eq. (1)

$$\mathrm{d} = \mathrm{c} * \frac{\Delta t}{2}, \tag{1}$$

where, d is distance, c is speed of light, Δt is time difference between emitted laser and reflected laser.

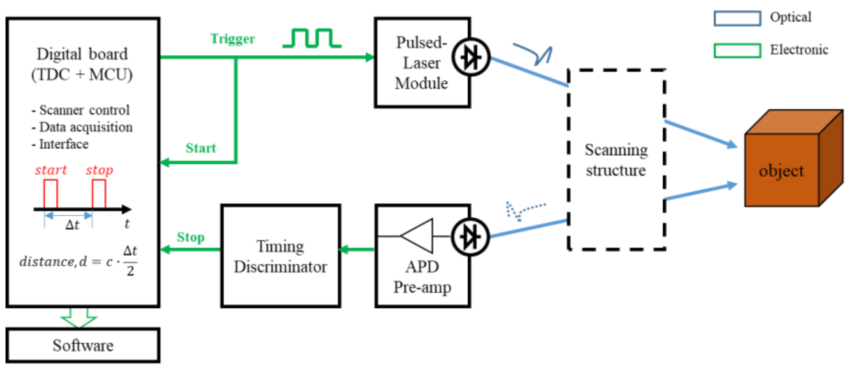


Fig. 3 Principle of the pulsed time-of-flight LiDAR

We design 3D LiDAR for wide angle scanning using polygon scanner as shown Fig. 4. In order to receive reflected laser at one point, the polygon scanner is used as vertical scanner.

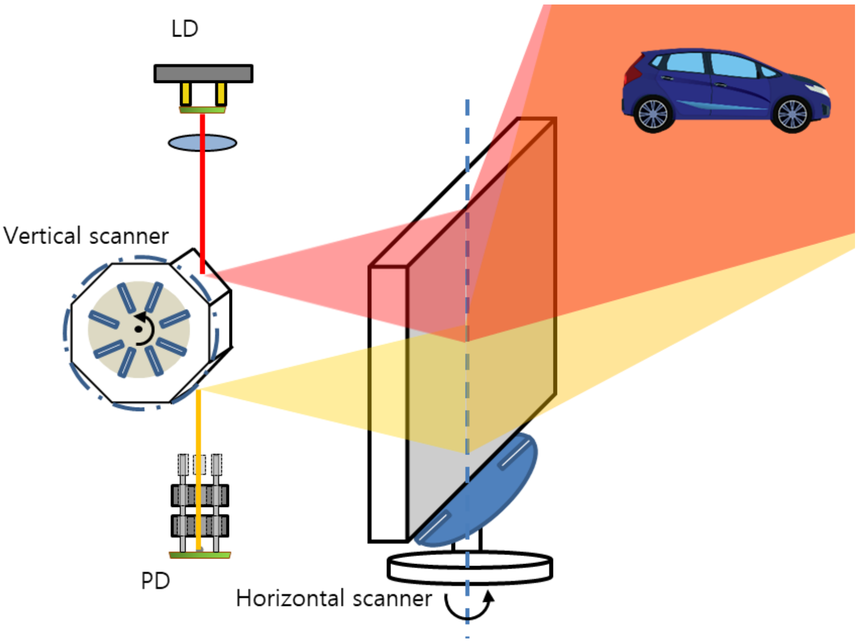


Fig. 4 3D LiDAR configurations using polygon scanner for wide angle scanning

Fig.5 shows the measurement result of designed 3D LiDAR.

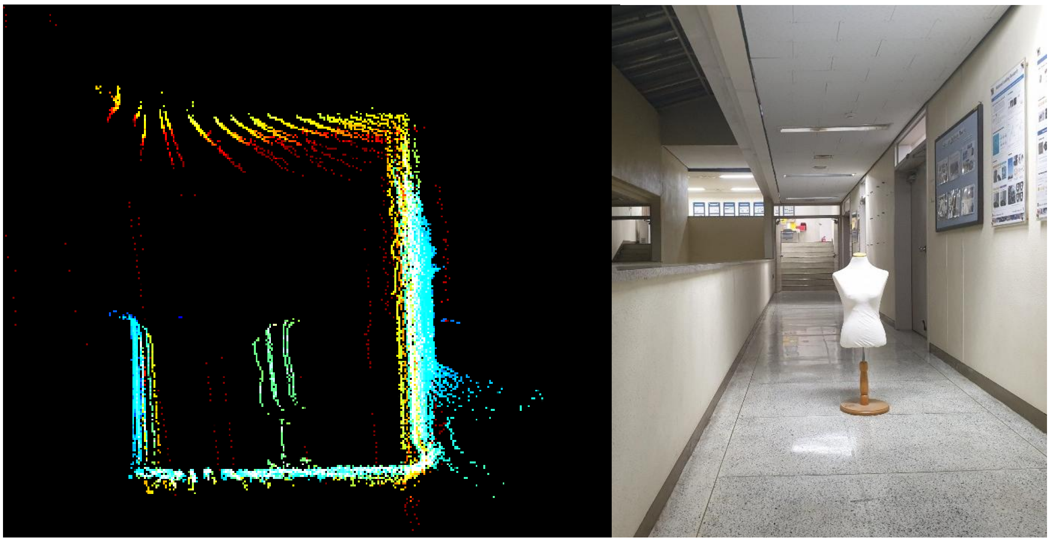


Fig. 5 The measurement result of designed 3D LiDAR

3. ADAPTIVE RADIUS OUTLIER REMOVAL ALGORITHM

When object is measured at far distance. The spatial resolution is very low due to angular scanning mechanism of LiDAR. The radius outlier removal algorithm does not properly work in this case. In order to overcome this limitation, the adaptive radios outlier removal algorithm is proposed as shown Fig. 6. Proposed method uses variable radius, R rather than fixed value and previous frames for neighbor points checking. The R is corresponding values to the distance of points so that all points are filtered well with different spatial resolution.

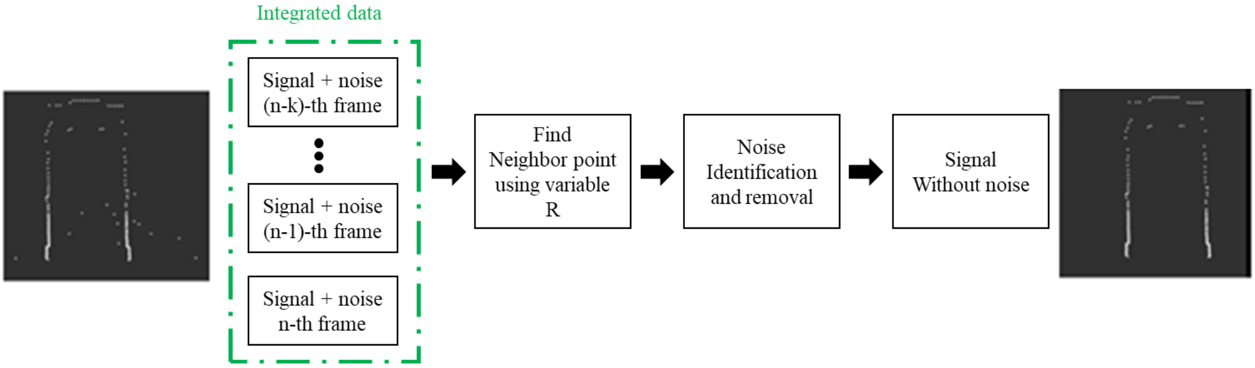
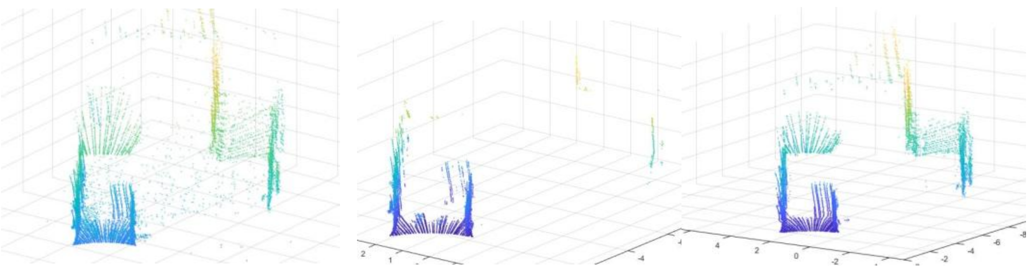


Fig. 6 The adaptive radius outlier removal algorithm

proposed method works properly with varying spatial resolution by distance as shown Fig. 7



(a) (b) (c)

Fig. 7 The adaptive radius outlier removal algorithm filtering result, (a) LiDAR data with simulated noise (b) ROR (c) Adaptive ROR

4. CONCLUSIONS

Almost conventional 3D LiDAR focused on autonomous driving with small vertical scanning angle. In this research, we design the 3D LiDAR for the wide scanning angle using polygon scanner. Also, we proposed adaptive radios outlier removal algorithm for LiDAR cloud point data. We expect it will open new LiDAR applications for outdoor.

5. ACKNOWLEDGEMENT

This work was supported by GIST Research Institute(GRI) grant funded by the GIST in 2019.

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