Gradient Field 기반 3D 포인트 클라우드 지면분할 기법

호앙 [1], 푸옹 [1], 조성재 [1], 장위강 [1], 문명운 [1], 심성대 [2], 곽기호 [2], 조경은 [1]*
[1] 동국대학교 멀티미디어공학과
[2] 국방과학연구소
*e-mail : cke@dongguk.edu (교신저자)

Gradient field based method for segmenting 3D point cloud

Hoang Vu[1], Phuong Chu[1], Seoungjae Cho[1], Weiqiang Zhang[1], Mingyun Wen[1], Sungdae Sim[2], Kiho Kwak[2], Kyungeun Cho[1]*
[1]Department of Multimedia Engineering, Dongguk University-Seoul
[2]Agency for Defense Development

요 약

This study proposes a novel approach for ground segmentation of 3D point cloud. We combine two techniques: gradient threshold segmentation, and mean height evaluation. Acquired 3D point cloud is represented as a graph data structures by exploiting the structure of 2D reference image. The ground parts nearing the position of the sensor are segmented based on gradient threshold technique. For sparse regions, we separate the ground and nonground by using a technique called mean height evaluation. The main contribution of this study is a new ground segmentation algorithm which works well with 3D point clouds from various environments. The processing time is acceptable and it allows the algorithm running in real time.

1. Introduction

In an autonomous robot system, a Lidar scanner outputs a 3D point cloud. From this data, robots need to segment ground and nonground regions. The ground segmentation is a pre-processing step of almost other higher processes. The objective of our study is to extract information from 3D point clouds and then group points with similar attributes into the ground or nonground part. At the present time, there are some done methods related to our work. Paper [2] proposes a method relied on local convexity. In [3, 4], the authors presented some methods based on an elevation map. Our novel ground segmentation algorithm relies on a combination of two techniques: gradient threshold segmentation [1], and mean height evaluation. We use region growing technique to segment the ground at regions near sensor's position. To deal with sparse regions, we apply the mean height evaluation technique which analyzes the mean of the height of ground neighbors.

2. Ground Segmentation Method

We consider 4 neighbors of each point. In the counter-clockwise system, a point's left and right neighbors correspond to the next and previous measurement obtained by the same laser diode. The upper and lower edges are assigned to the measurements of the upper and lower laser beam with the most similar yaw angle, respectively.

We use the gradient quantity as the basic feature in our algorithm. The gradient field calculation process requires two assumptions. First, the ground is observed around the sensor. Second, there is at least one part of closest line of data (data from lowest laser diode) placing in the ground region. From each point P_i, we visit its neighbor sum up all the distances.

For segmentation, we employ region growing technique. The algorithm starts from a set of seeds. The seed S_0 is the longest sequence of points of the nearest line whose gradient values is smaller than constant value *maxGradient.* This constant value depends on the terrain properties. S_k is another sequence of points in the nearest line. If the height difference between two nearest points which belong to two sequences S_0 and S_k is smaller than *maxHeight*, S_k is pushed in the seed group. All points in the seeds are ground ones. The ground part is grown from these seed points by considering other scan lines. A point is labeled as ground if its gradient value is below *maxGradient* and at least one of its direct neighbors already identified as ground point.

The region growing technique works well in the area nearing the sensor's position. However, it is difficult to segment the ground in the sparse area because there is no connection between segmented regions. To solve this problem, we use another technique called mean height evaluation. This technique works as a sliding window which analyzes the height of every 3D points in a predefined region, and compares them with the mean height of every segmented ground points in it. We define a region as a cube with appropriate sizes. If P is not labeled as ground point, we compare the height of p and the mean height of all segmented ground point placing inside the cube. If the difference is smaller than *maxHeight*, we mark p as ground point. However, this technique is computational expensive with big size and unordered data. We overcome this problem by using the graph representation which exploits the order of the scan lines. To avoid a bias segmentation, this technique is employed in only sparse areas.

3. Experiments and analysis

For our experiment, we employ a Velodyne HDL-32 scanner mounted on the top of our robot. It returns a point cloud with approximately 700,000 points per second. We analyze the true positive rate of our algorithm with manual ground truth data. The result of the first stage of our algorithm is 76% when we apply naïve gradient field technique to segment the ground points. Fig. 1 shows the final result of our algorithm. The result is about 82 %. The time consuming is about 30 millisecond per frame.

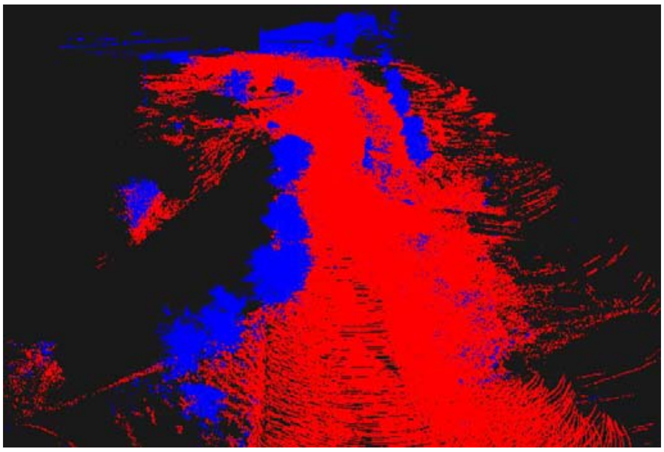

Fig. 1. Ground segmentation result.

4. Conclusion

In this paper, we proposed a novel approach for ground segmentation relied on gradient field. The experiments show that our method achieves good results in both quality and processing time. In future work, we will enhance the algorithm for decreasing processing time and improving quality.

Acknowledgements

This research was supported by BK21 Plus project of the National Research Foundation of Korea Grant and was supported by a grant from Agency for Defense Development, under contract #UD150017ID.

Reference

[1] B. Douillard, J. Underwood, N. Kuntz, V. Vlaskine, A. Quadros, P. Morton, A. Frenkel, "On the segmentation of 3d lidar point clouds," *International Conference on Robotics and Automation (ICRA 2011)*, pp. 2798–2805, 2011.

[2] F. Moosmann, O. Pink, and C. Stiller, "Segmentation of 3d LIDAR data in non-flat urban environments using a local convexity Criterion," *IEEE Intelligent Vehicles Symposium*, pp. 215-220, 2009.

[3] B. Douillard, J. Underwood, N. Melkumyan, S. Singh, S. Vasudevan, C. Brunner, and A. Quadros, " Hybrid elevation map: 3d surface models for segmentation," *IEEE International Conference on Intelligent Robots and System (IROS)*, 2010.

[4] S. Thrun, "Stanley: The robot that won the DARPA grand challenge," *Journal of Filed Robotics (JFR)*, pp. 661-692, 2006.