Segmentation of point cloud data

by
KATTA ROHITH(19JE0428)
ANAND DESHMUKH(19JE0124)

SUPERVISOR
Prof. Kailash Jha
Associate Professor
Mechanical Department

introduction

Point cloud data:

A point cloud is a set of data points in space representing a 3D object having its own cartesian coordinates (X , Y , Z). Point cloud is the group of key points of any object which together can define its shape and size.

Segmentation:

3D point cloud segmentation is the process of classifying point clouds into multiple homogeneous regions, the points in the same region will have the same properties.

Applications:

1.In reverse engineering-based manufacturing,
2.For surveying of large area like any construction site, buildings,farm areas,natural places etc.
3.This method can be utilized as a helping tool in solving industrial problems like to detect any defect in any machine part,sorting the geometrical data of machine parts in the form of segmented point cloud. 4.Reconstruction of any surface and 3D model of machine parts and tool.
5.Feature curve extraction.

Objective:

To segment the 3D point cloud of staircase model and cubical box into multiple regions based on similar attributes.The attributes used here are normal vectors computed for each point in point cloud.

Experimental Setup

1.Cardboard box used as model for 3D scanning

2.3D scanner.

3.3D zephyr software for post processing of point cloud.

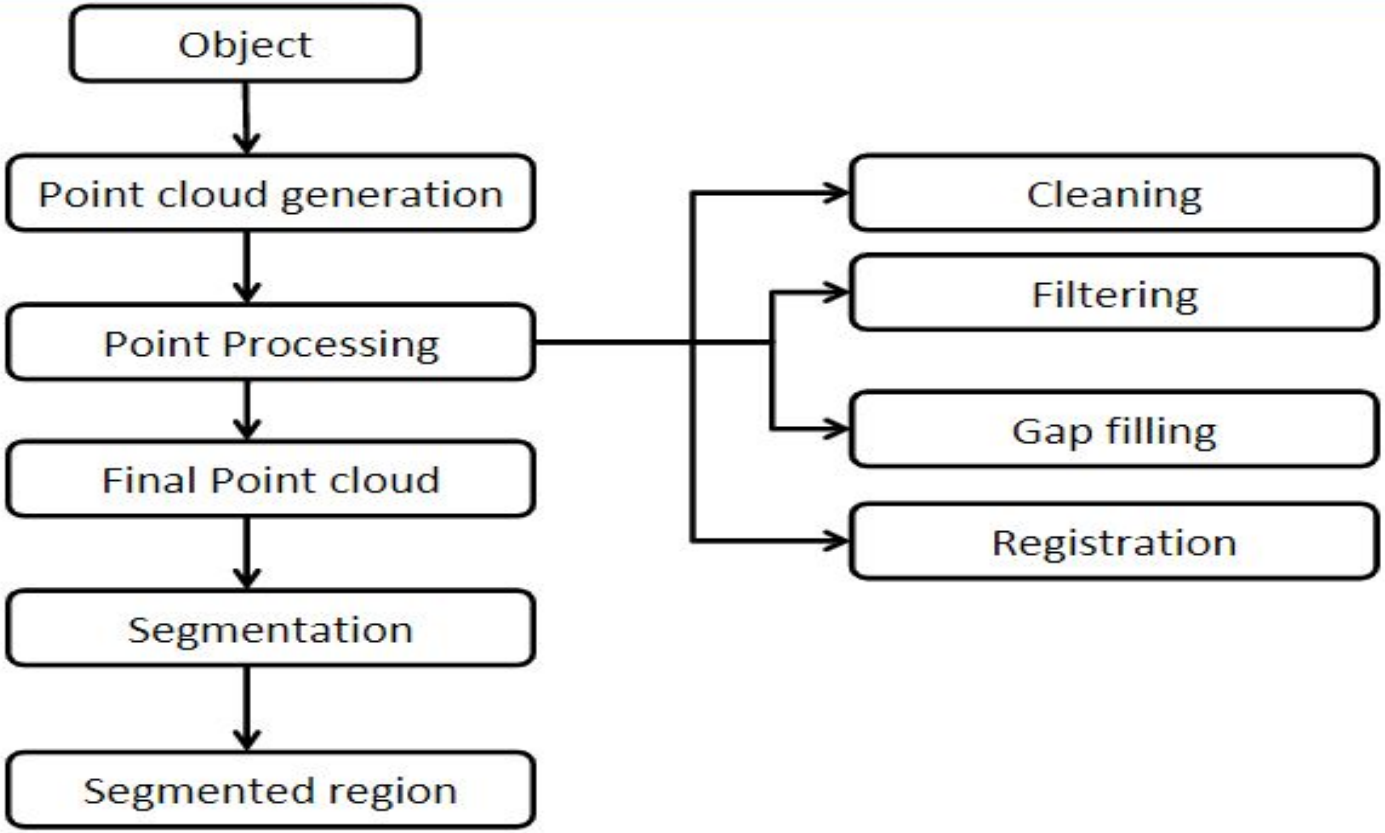
4.Algorithm for computation of Normals vectors using C++ language

5.Segmentation of algorithm written using Python language which uses machine learning and visualization libraries :

1.NearestNeighbour for k-nn algorithm.

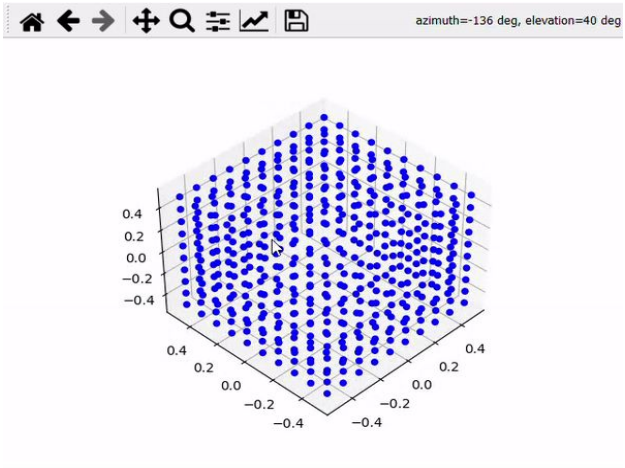
2.matplotlib for visualization.

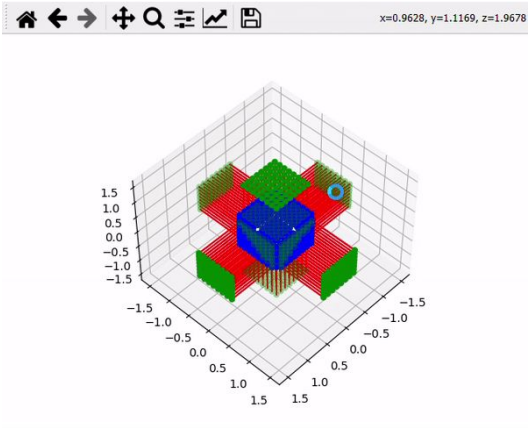
Methodology:

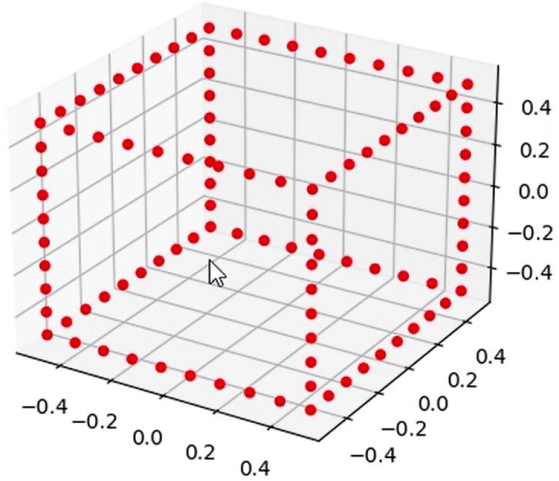


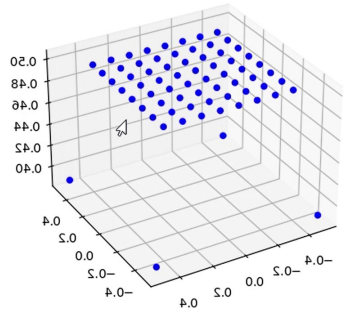
Results

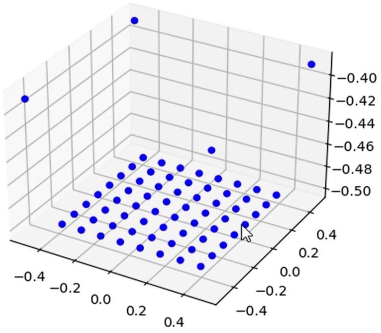
1.Result for cubical dataset.

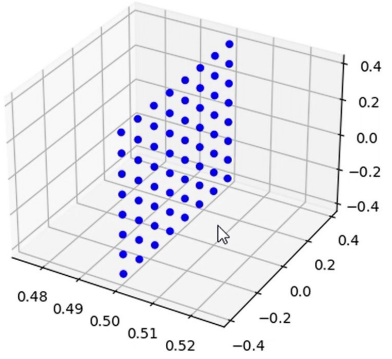


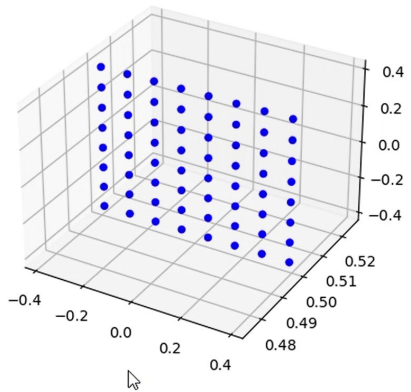


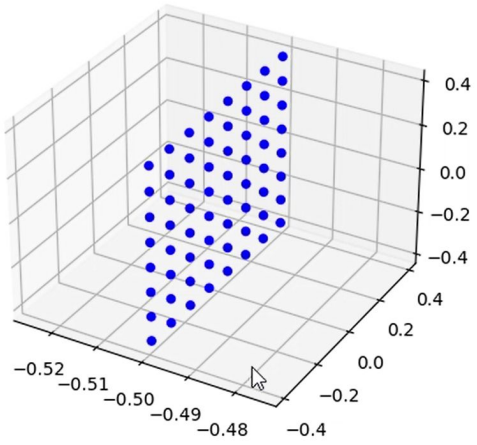


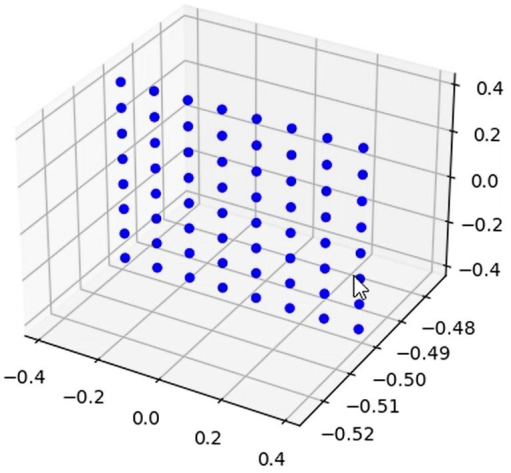

0.50
0.48
0.46
0.44
0.42
0.40
0.4
0.2
0.0
−0.2
−0.4
−0.4
−0.2
0.0
0.2
0.4

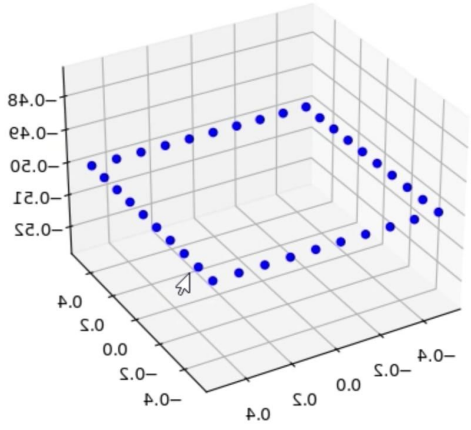

−0.40
−0.42
−0.44
−0.46
−0.48
−0.50
0.4
0.2
0.0
−0.2
−0.4
−0.4
−0.2
0.0
0.2
0.4

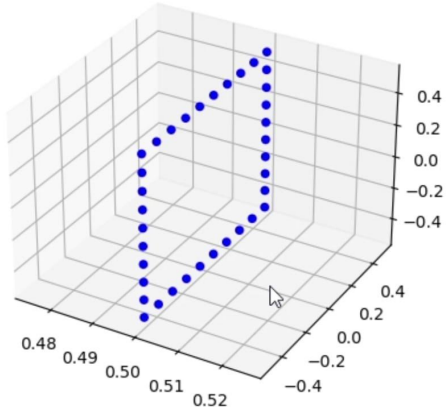

0.4
0.2
0.0
−0.2
−0.4
0.48
0.49
0.50
0.51
0.52
0.4
0.2
0.0
−0.2
−0.4

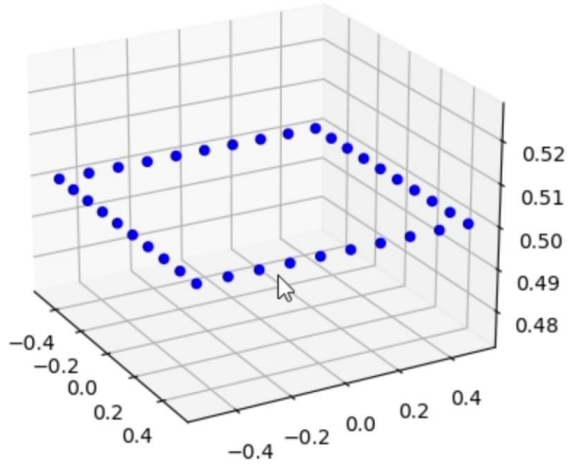

0.4
0.2
0.0
−0.2
−0.4
0.52
0.51
0.50
0.49
0.48
−0.4
−0.2
0.0
0.2
0.4

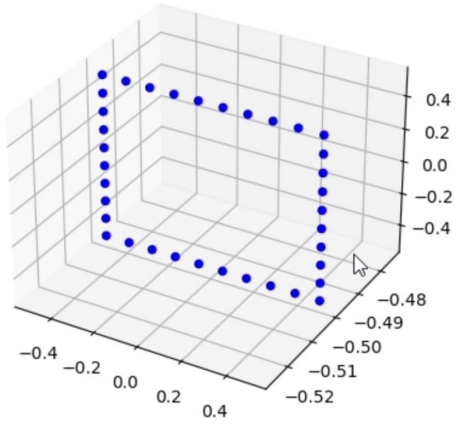

0.4
0.2
0.0
−0.2
−0.4
0.4
0.2
0.0
−0.2
−0.4
−0.52
−0.51
−0.50
−0.49
−0.48

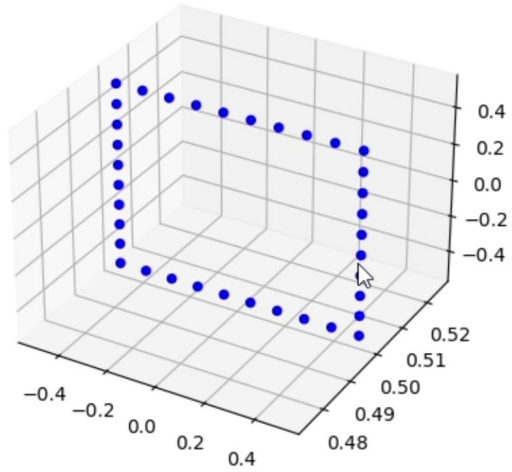

0.4
0.2
0.0
−0.2
−0.4
−0.48
−0.49
−0.50
−0.51
−0.52
−0.4
−0.2
0.0
0.2
0.4

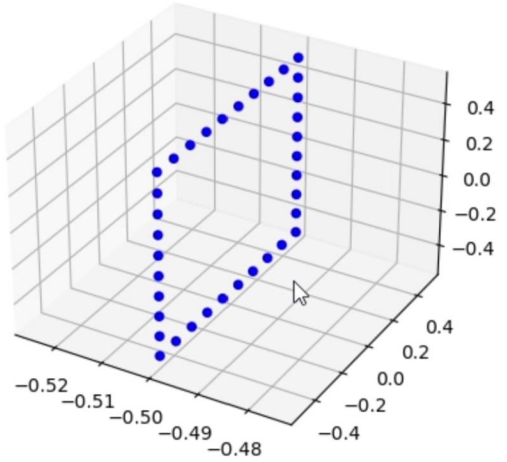

−0.48
−0.49
−0.50
−0.51
−0.52
0.4
0.2
0.0
−0.2
−0.4


0.4
0.2
0.0
−0.2
−0.4
0.48
0.49
0.50
0.51
0.52

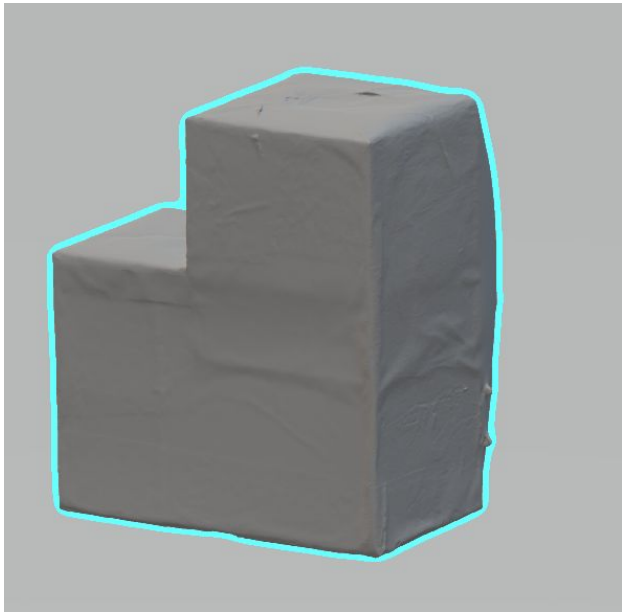

0.52
0.51
0.50
0.49
0.48
−0.4
−0.2
0.0
0.2
0.4


0.4
0.2
0.0
−0.2
−0.4
−0.48
−0.49
−0.50
−0.51
−0.52

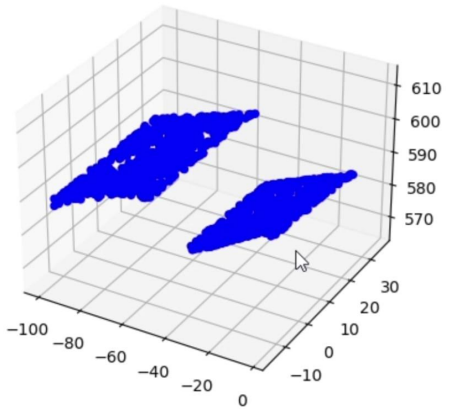

0.4
0.2
0.0
−0.2
−0.4
0.52
0.51
0.50
0.49
0.48

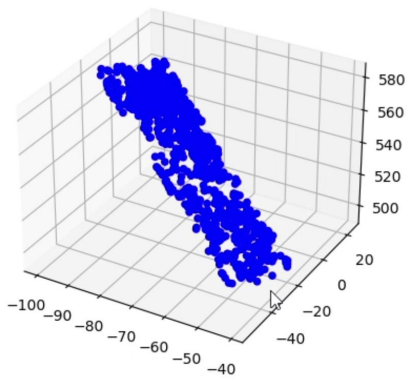

0.4
0.2
0.0
−0.2
−0.4
−0.52
−0.51
−0.50
−0.49
−0.48

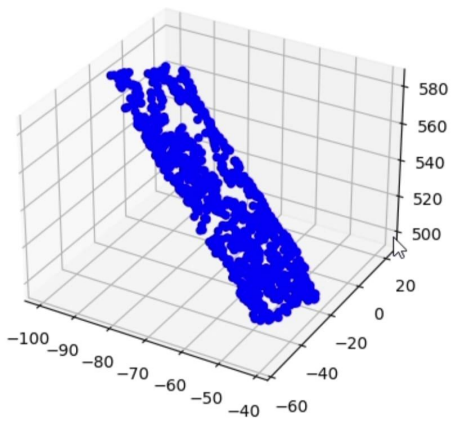
Result for staircase model

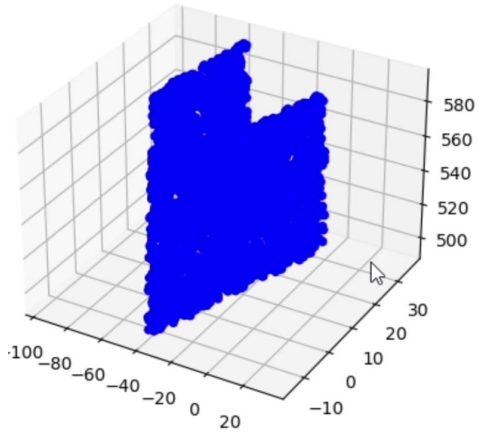


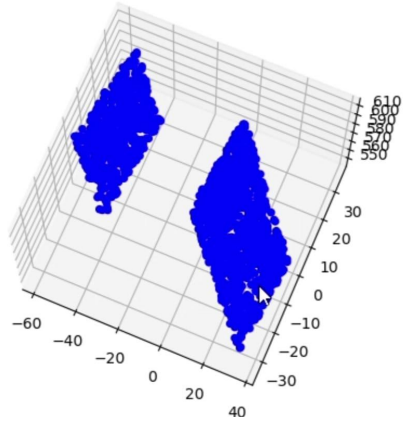
This is an STL file of staircase model which is later Converted to 3D point cloud using 3DF zephyr Software and the outlier points were removed Using the same software.normal vectors are Generated for each of these points .The generated Normal vectors and points are used for further segmentation.

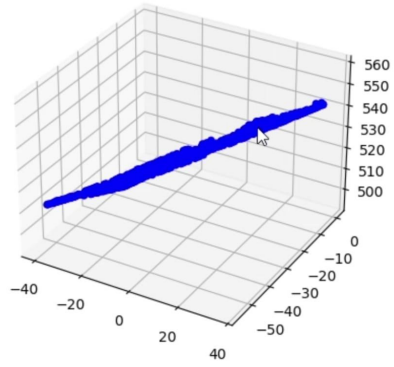

610
600
590
580
570
−100 −80 −60 −40 −20 0
30 20 10 0 −10

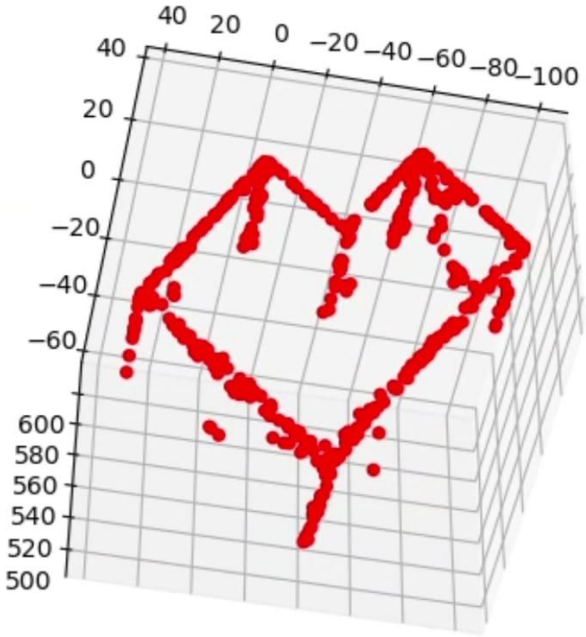

580
560
540
520
500
−100 −90 −80 −70 −60 −50 −40
20 0 −20 −40


580
560
540
520
500
−100 −90 −80 −70 −60 −50 −40 −60
20 0 −20 −40


580
560
540
520
500
−100 −80 −60 −40 −20 0 20
30 20 10 0 −10


610
600
590
580
570
560
550
−60 −40 −20 0 20 40
30 20 10 0 −10 −20 −30


560
550
540
530
520
510
500
−40 −20 0 20 40
0 −10 −20 −30 −40 −50



Edge points exhibit a significant change In some attributes such as depth,color, Or intensity .The significance of edge Points lies in their ability to provide Important cues for distinguishing betw--een different regions .by identifying And analyzing these edge points ,segm--entation algorithms can leverage the Information about spacial discontinuit-- ies to separate distinct objects or regi--ons within the point cloud.

Conclusion

This paper presents a normal-based segmentation technique for 3D point clouds, which effectively partitions the point cloud into meaningful regions or objects.Here, in the present work cubical dataset is a test data set used to check the functionality of the algorithm while staircase dataset is the main dataset which is obtained by scanning through 3D scanners.Staircase has eight faces. The normal generation is time consuming as the staircase dataset contains over 9000 points and the point cloud, we obtained for staircase model has numerous outlier points which we were able to pre-process and the post-processed dataset was subjected to segmentation. The proposed approach can be used significantly for numerous applications in computer vision, robotics, and reverse engineering where accurate segmentation of 3D point clouds is essential.

Future works

The attribute used for segmentation here is normal based segmentation but for robust results we can use Feature-based segmentation where extracting meaningful features from curvature and deep learning based segmentation.

References

1. Grilli, E., Menna, F., & Remondino, F., 2017. A REVIEW OF POINT CLOUDS SEGMENTATION AND CLASSIFICATION ALGORITHMS. ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 339-344.

2. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 2019, Volume XLII2/W15, 2019 27th CIPA International Symposium “Documenting the past for a better future”, 1–5 September 2019, Ávila, Spain.

3. Klasing, K., Althoff, D., Wollherr, D. and Buss, M., 2009. Com- parison of surface normal estimation methods for range sensing applications. Proc. IEEE International Conference on Robotics and Automation, pp. 3206–3211.

4. Lu, X., Yao, J., Tu, J., Li, K., Li, L., & Liu, Y., 2016. Pairwise Linkage for Point Clouds Segmentation. ISPRS Annals of Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol.III(3), pp. 201-208.

5. Sapkota, P. P., 2008. Segmentation of Coloured Point Clouds Data. PhD Thesis, International Institute for Geo-Information Science and Earth Observation, Enschede, The Netherlands.

6. Sappa, A. D., & Devy, M., 2001. Fast range image segmentation by an edge detection strategy. Proc. IEEE 3rd 3-D Digital Imaging and Modeling, pp. 292-299.

7. Sithole, G. and Vosselman, G., 2004. Experimental comparison of filter algorithms for bare-Earth extraction from airborne laser scanning point clouds. ISPRS Journal of Photogrammetry and Remote Sensing, Vol. 59(1), pp.85-101.