HW 3: Point Cloud Analysis

CS 4610/5335: Robotic Science and Systems (Spring 2024)

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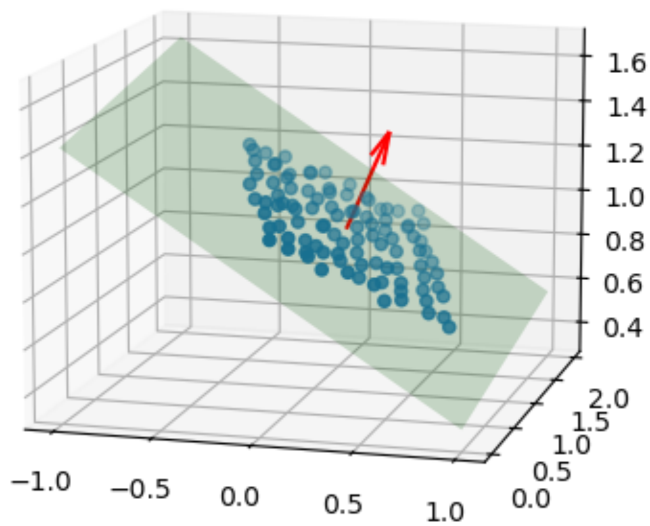
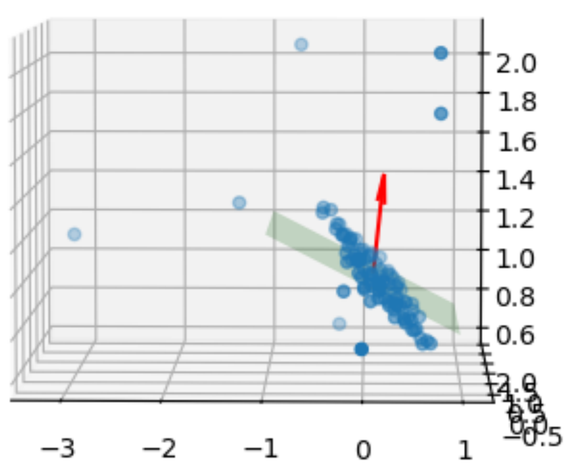
Ans 1 (a)

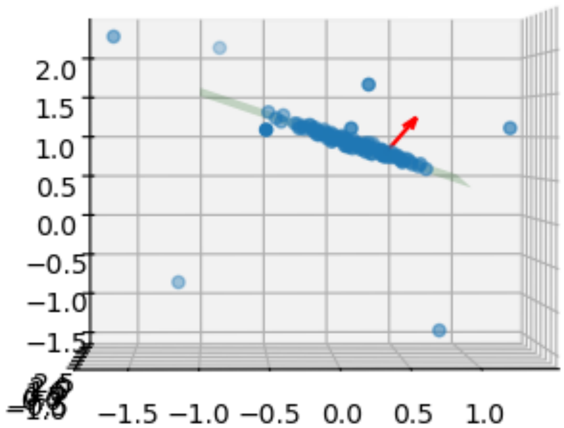


Ans 1(b)



How this different from the result in part (a) and why?
Ans. Outliers affect the sample mean which in-turn affects the covariance matrix as they increase the spread of the data. This has an impact on the eigen Values and eigen Vectors and since the normal vector is determined by the eigen Vector corresponding to the smallest eigen Value, the resulting surface normal change. Hence, presence of outliers causes changes to the fitting plane in that the plane doesn't seem to fit all the points well within itself.

Ans 1(c)

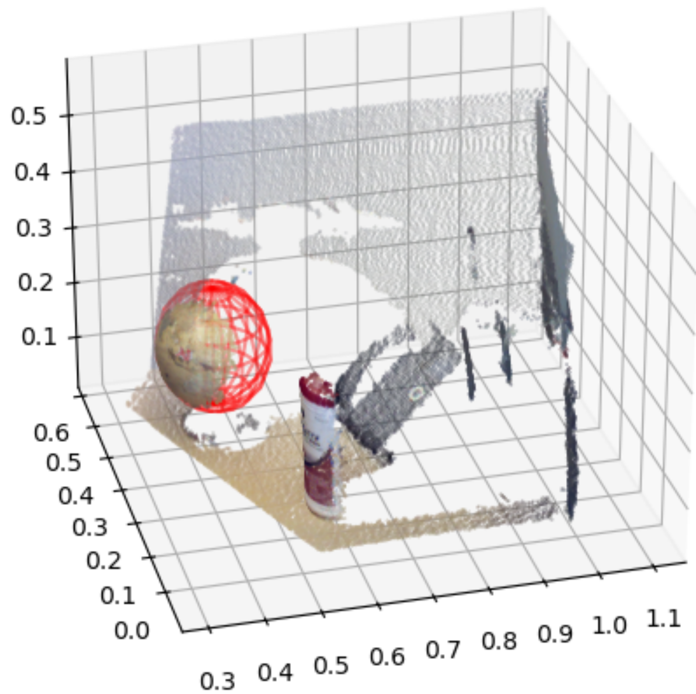


RANSAC algorithm was used to fit a plane to the given point cloud dataset. This was done by sampling candidate 3 points and then, all the points that were within a certain threshold of this plane were considered as inliers while others were considered outliers. This process was repeated for multiple iterations so as to find the plane with maximum inliers.

What are the strengths and weaknesses of each approach?
Ans.
The strengths of **RANSAC** are that it is highly robust to outliers and can generate decent results in the presence of noisy data. This is the reason why this algorithm works well in practice. On the other hand, its downside is that it is computationally expensive as sometimes a high number of iterations might be required. Another weakness of RANSAC is that it can fail for a very low inlier ratio.

The strengths of **covariance-based** approach are that it is simple to implement and is computationally very cheap. It works really well when the data is smooth and does not contain too many outliers. Whereas, its weaknesses are that it is highly susceptible to outliers and it can give really bad results when the data is noisy. Also, it is not able to produce good results if the data contains complex geometric features.

Ans 2)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0.4
0.3
0.2
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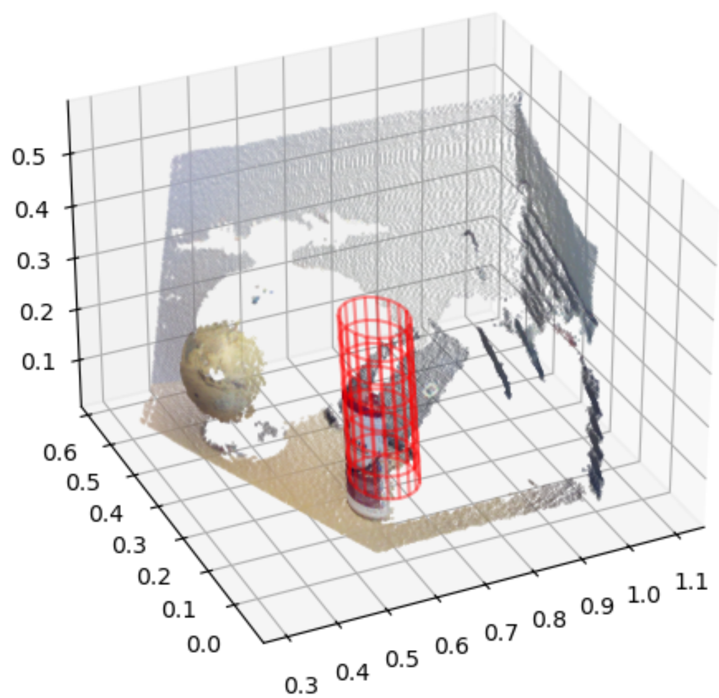
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1

Ans 3)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0.4
0.3
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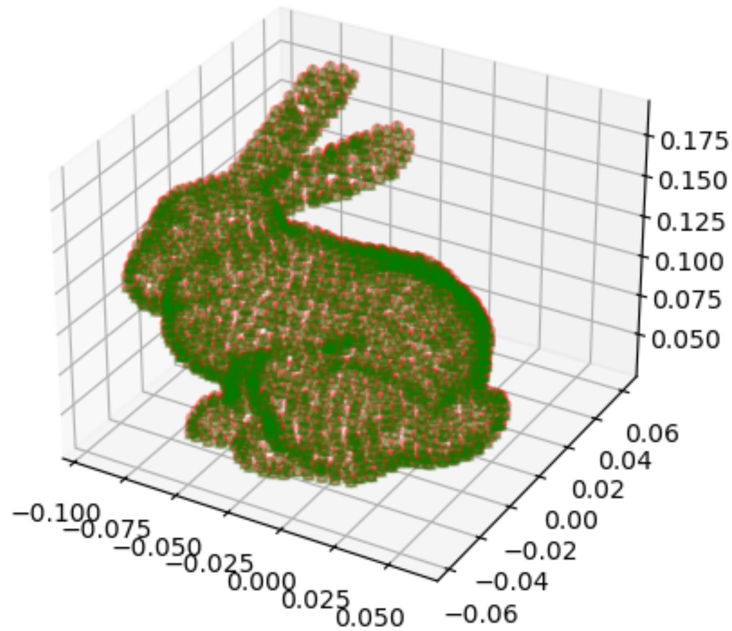
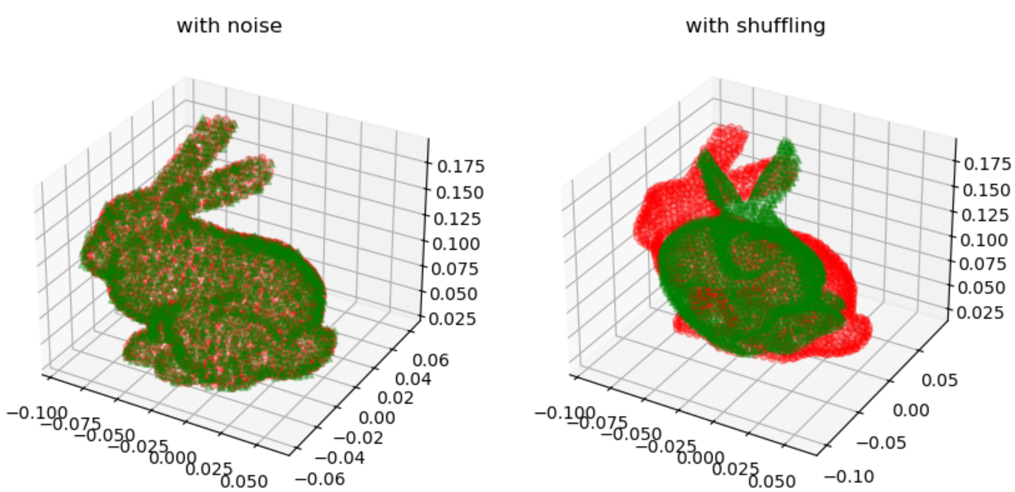
0.6
0.7
0.8
0.9
1.0
1.1

Ans 4(a)



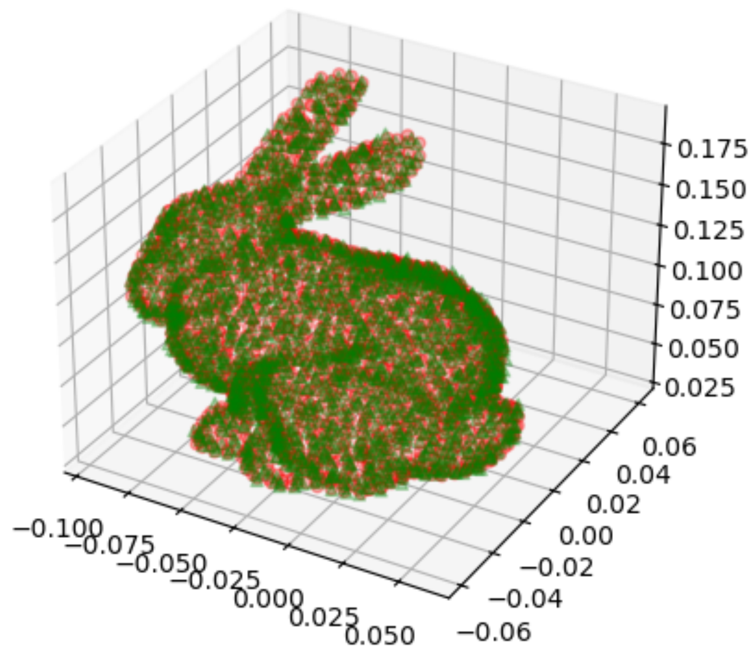
Ans 4(b)



(b) Explain why the algorithm still works when gaussian noise is added to one of the point clouds, but does not work when the order of the points is shuffled.

Ans. This part of the question applies noise to the input of the previous question. When gaussian noise is added to one of the input point clouds, it affects each point separately and hence, the correspondences between the points in the two point clouds is not affected. Therefore, the ICP is able to find the minimum distance between corresponding points and generate a decent result. However, when the points are shuffled, the correspondence between the points is lost and ICP is no longer able to generate a suitable transformation matrix and hence fails to produce a good result.

Ans 4(c)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0.06
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0.02
0.00
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−0.04
−0.06
−0.100
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0.025
0.050