CS 5335: Robotic Science and Systems (Spring 2023)
HW 4: Point Cloud Analysis

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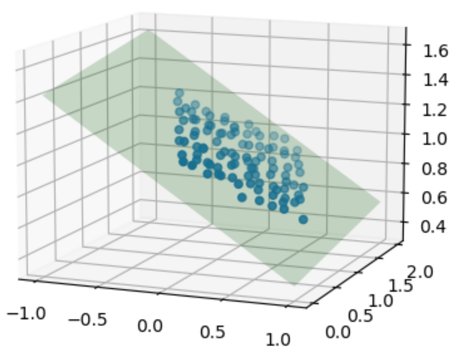
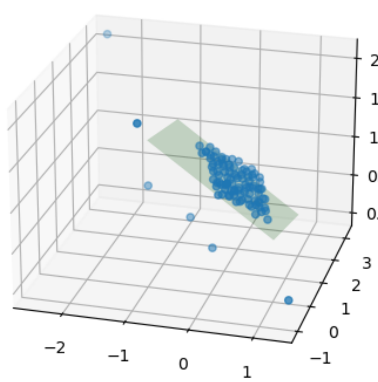
Q1)

a)

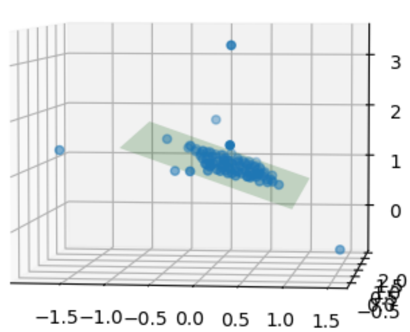


b)



The presence of outliers can greatly affect the sample mean and covariance matrix. Outliers are points that deviate significantly from the majority of the points, resulting in an incorrect plane fitting as they can skew the calculation of the mean and covariance.

c)



The strengths of the RANSAC-based approach are:

1. Robustness: RANSAC is a better algorithm to provide accurate estimates of plane parameters when outliers are present.
2. Automation: RANSAC does not require manual tuning of the parameters so it is a lot more automated.

The weaknesses of the RANSAC-based approach are:

1. Computationally intensive: RANSAC multiple iterations and model fitting can be computationally intensive especially for large data.
2. Randomness: RANSAC is a stochastic algorithm that depends on the random selection of subsets, hence it might give slightly variable results for each run.

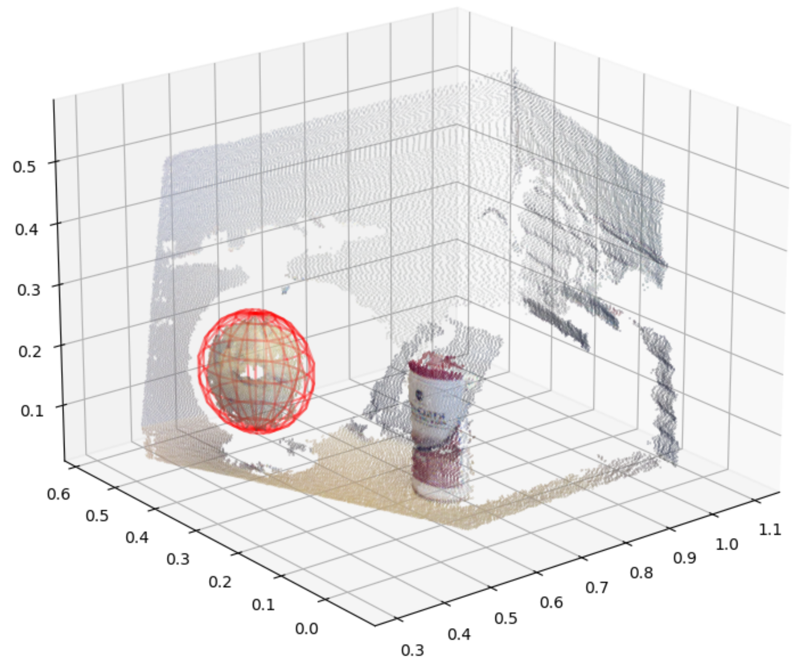
The strengths of the sample mean and covariance-based approach from part (a) are:

1. Simplicity: The sample mean and covariance-based approach is a simple and straightforward method that can be easily implemented.
2. Efficiency: The sample mean and covariance-based approach is computationally efficient and can provide a good estimate of the plane parameters for small datasets.

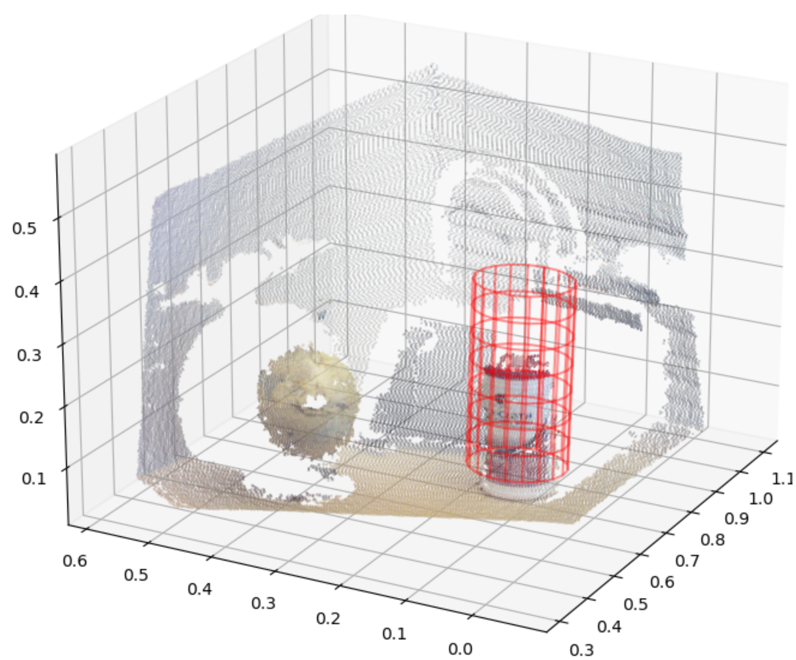
The weaknesses of the sample mean and covariance-based approach are:

1. Sensitivity to outliers: The sample mean and covariance-based approach can be sensitive to outliers, which can lead to an inaccurate estimate of the plane parameters.
2. Manual tuning: The sample mean and covariance-based approach requires manual tuning of the number of points to include in the covariance matrix, this affects the accuracy of the estimate.

Q2)


0.5
0.4
0.3
0.2
0.1
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1

Q3)


0.5
0.4
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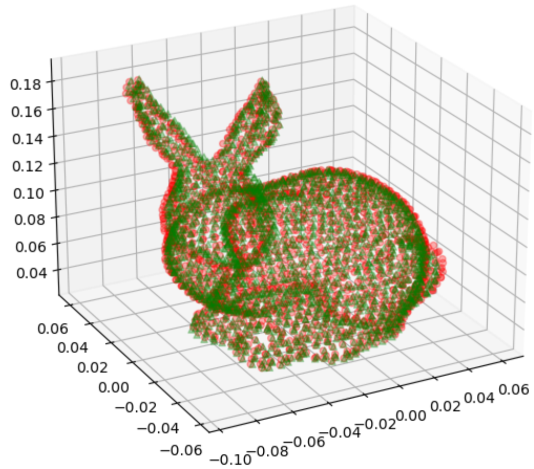
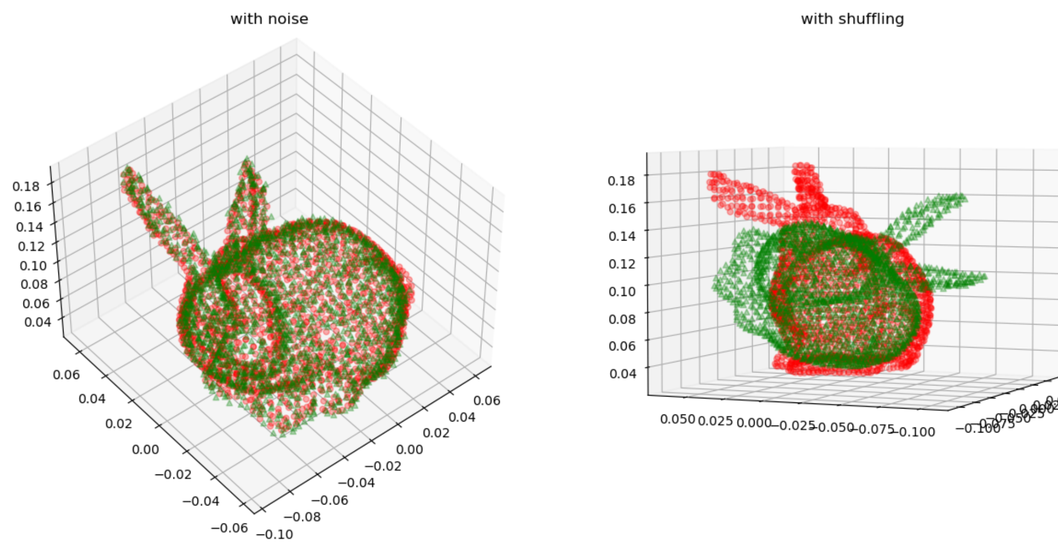
0.8
0.9
1.0
1.1

Q4)

a)



b)



Assuming that each point in one set corresponds to a point in the other, the algorithm finds the rotation and translation that best aligns two sets of points.
To do this, the points are first centered to eliminate any translation, and then the rotation and translation that best align the centered points are found using SVD.

The algorithm is unaffected by the addition of Gaussian noise because centering the points removes any translation and the noise has zero mean. The SVD calculation is still accurate as a result.

However, shuffling the order of the points breaks the assumption that each point in one set corresponds to a point in the other set. This means that the calculated rotation and translation may not align the correct points in the two sets, leading to an incorrect transformation matrix.

c)