Questions

1. 
2. Explain why it is more difﬁcult to deﬁne a distance metric that leads to good performance for a non-holonomic motion planning problem than a holonomic one. Use a car as an example that illustrates this difﬁculty and include diagrams.

Non-holonomic problem is harder to move around since its available motion is limited. For example, a car is limited in forward, reverse, and turning in curve with a maximum curvature which means move to a location sideway is harder for a car that it needs to go forward, turn a bit, then backward. In comparison, a holonomic vehicle could simply rotate to the direction of goal then move forward. Because of that, a distance metric for non-holonomic should consider which step is available and it is not suitable to use a simple Euclidean distance metric that holonomic vehicle uses.

1. Consider a robot ﬁnger making a point contact on a plane made of homogeneous material. The friction coefﬁcient between the ﬁnger and the plane is unknown and we would like to determine it. Assume that the robot can apply any force at the contact point and can sense the position of the contact point perfectly. Assuming the standard Coulomb friction model, write down an algorithm in pseudo-code for applying a series of forces at the contact that would determine the friction coefﬁcient.

Assuming the plane is fixed.

Given a constant force with direction in the normal direction of the plane

Tangent force = 0

While True

Increase the tangent force that finger applied

If position of contact point changed

Friction coefficient = current tangent force / normal force

Return Friction coefficient

Implementation

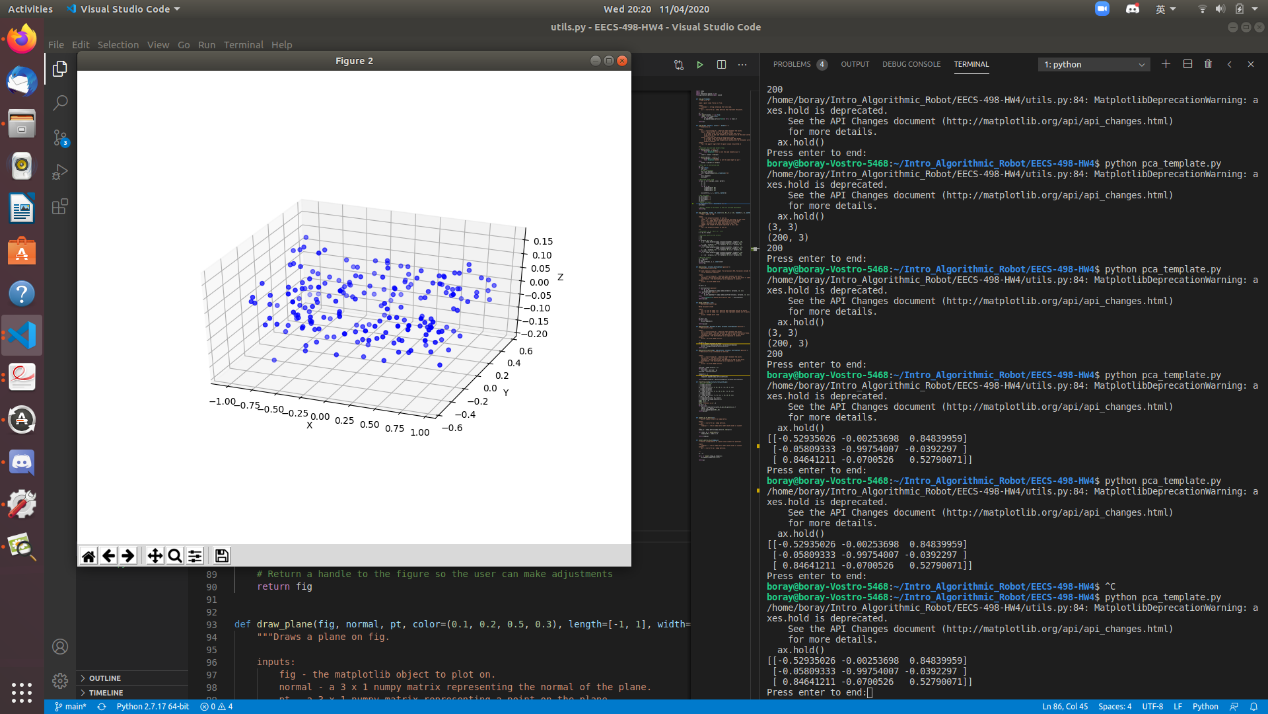
1. (c)Iterative Jacobian Pseudo-Inverse Inverse Kinematics

|  |  |
| --- | --- |
| Target 0 | Target 1 |
|  |  |
| Target 2 | Target 3 |
|  |  |
| Target 4 |  |
|  |  |

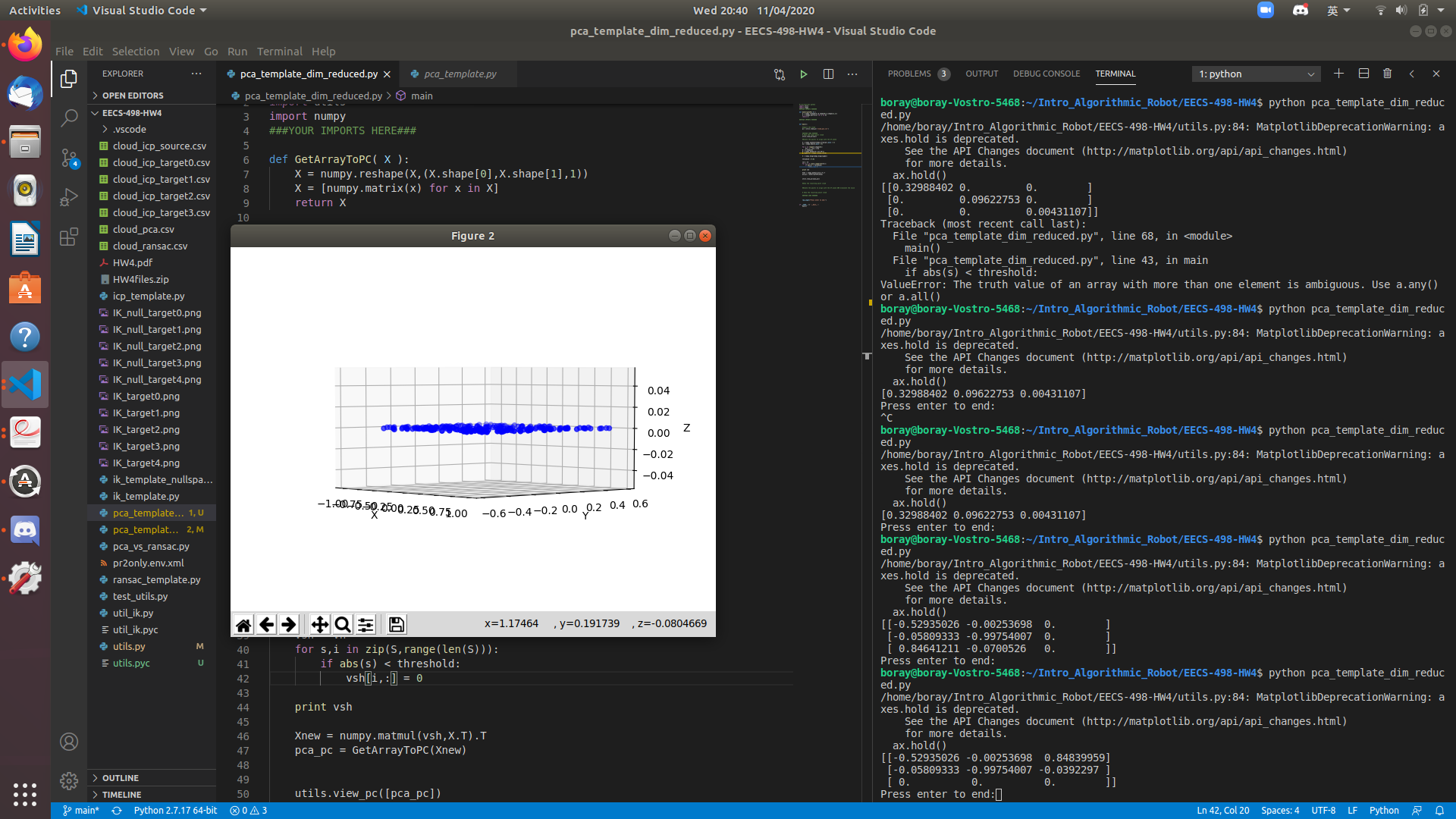
(d)IK with left null-space of the Jacobian pseudo-inverse

|  |  |
| --- | --- |
| Target 0 | Target 1 |
|  |  |
| Target 2 | Target 3 |
|  |  |
| Target 4 |  |
|  |  |

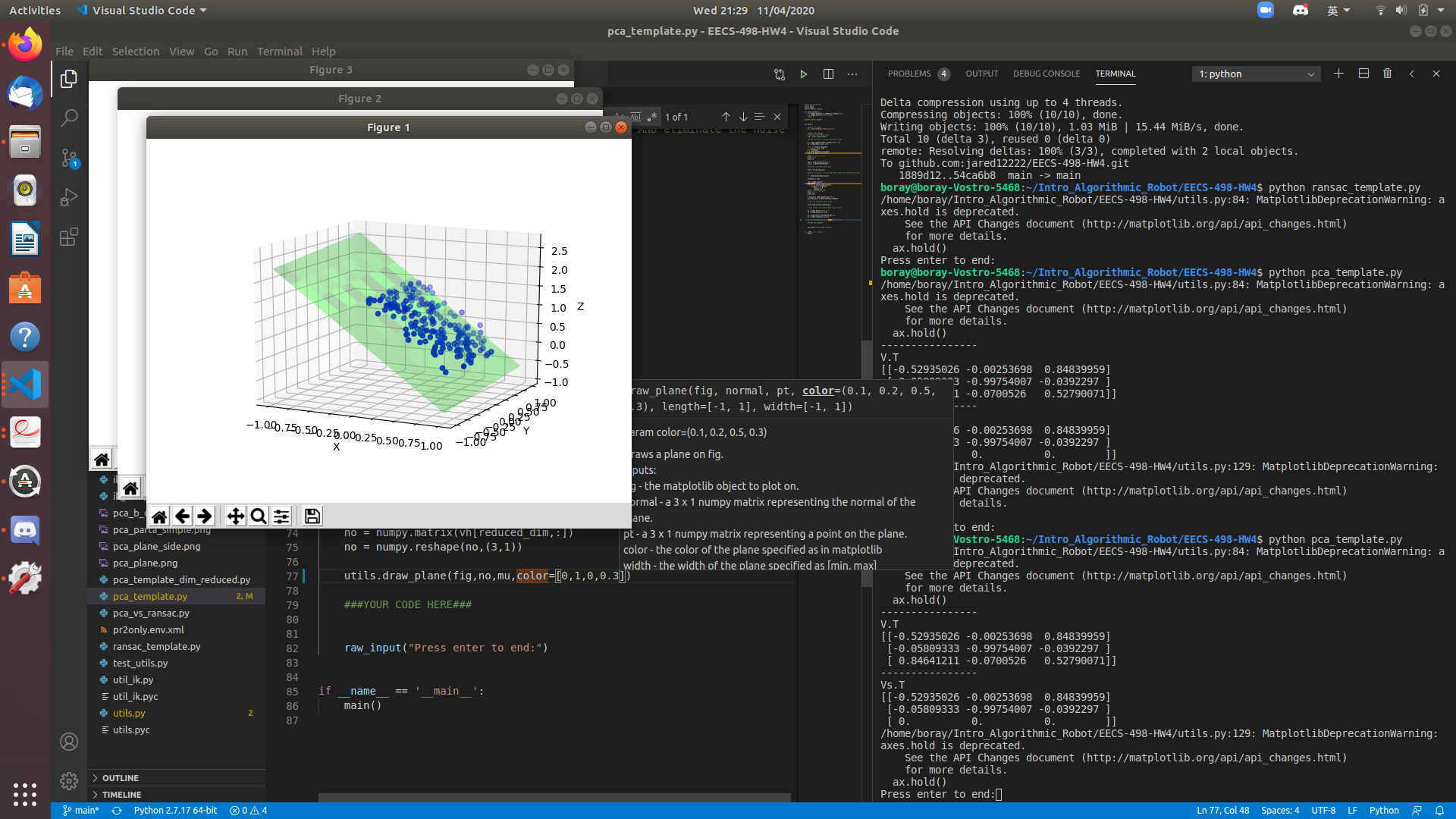
1. (a) PCA



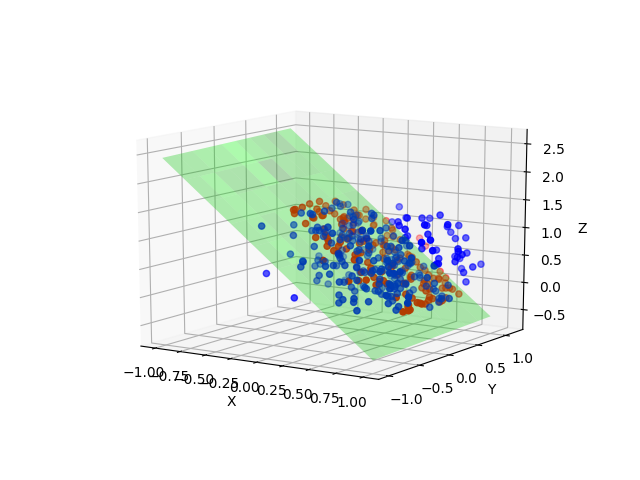
(b) Noise elimination



(c) Plane fitting

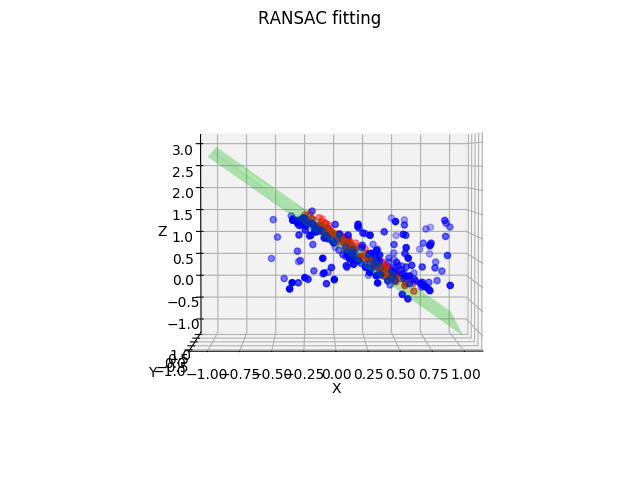
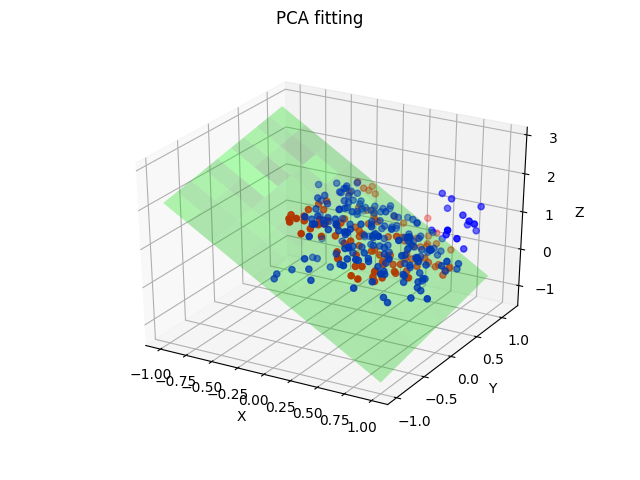


1. RANSAC

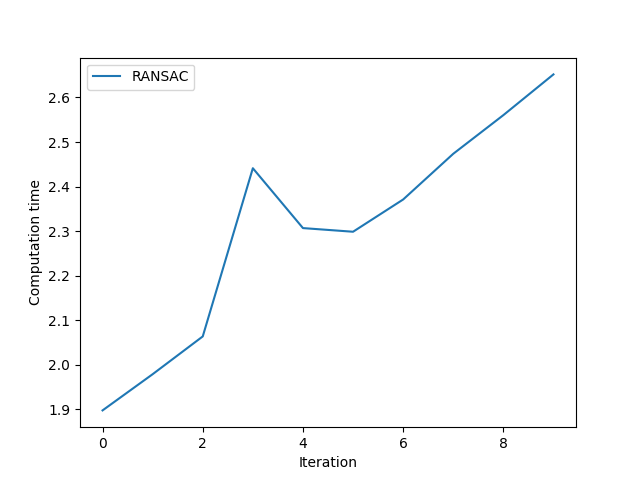
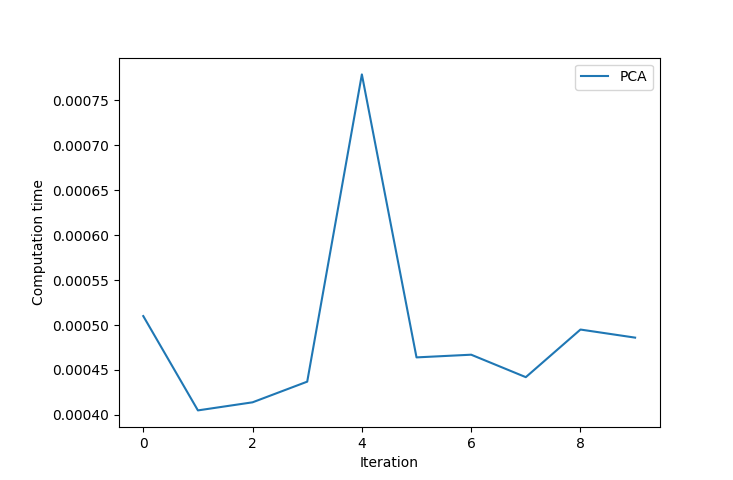


Plane equation:

1. PCA vs RANSAC



Number of Outliers vs Error

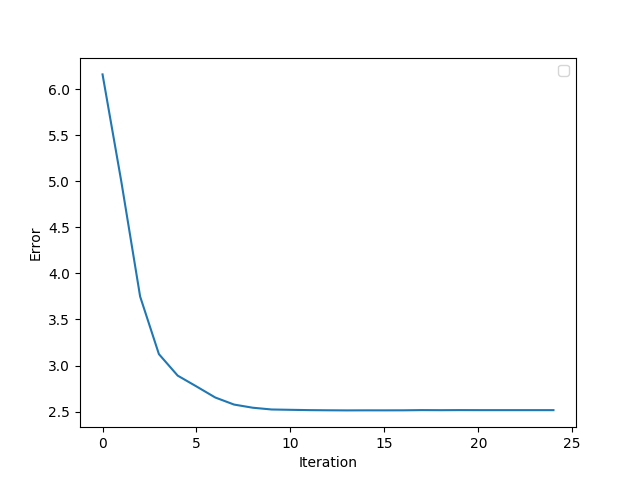
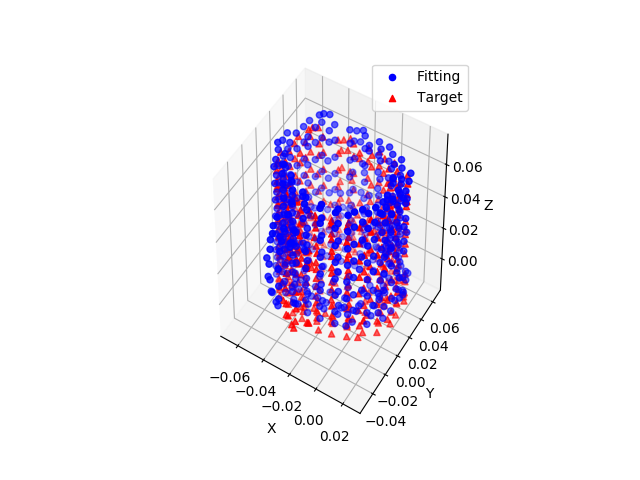


Computation Time of PCA and RANSAC

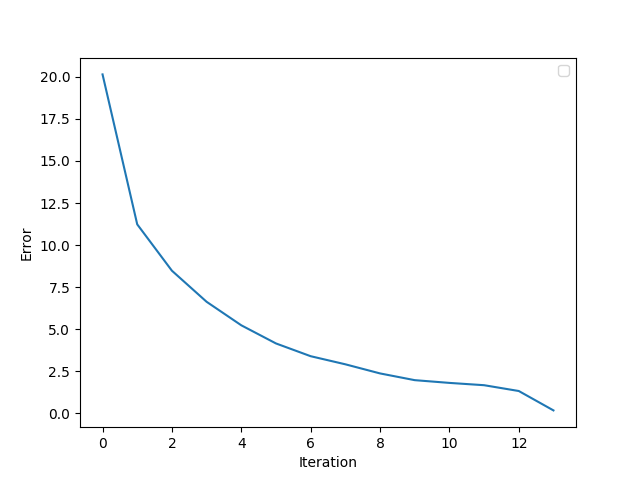
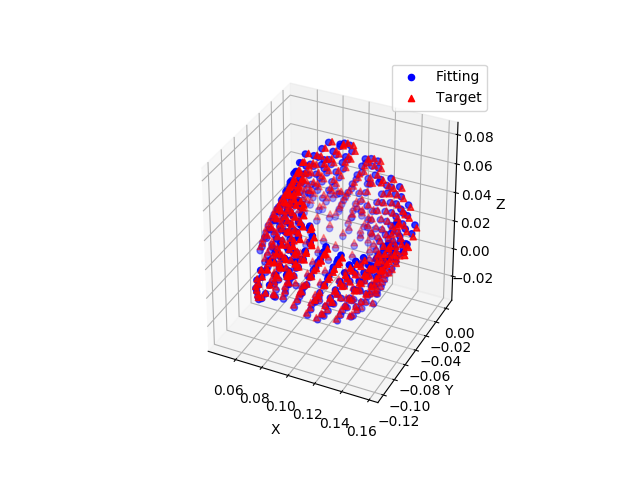
Discussion

1. ICP

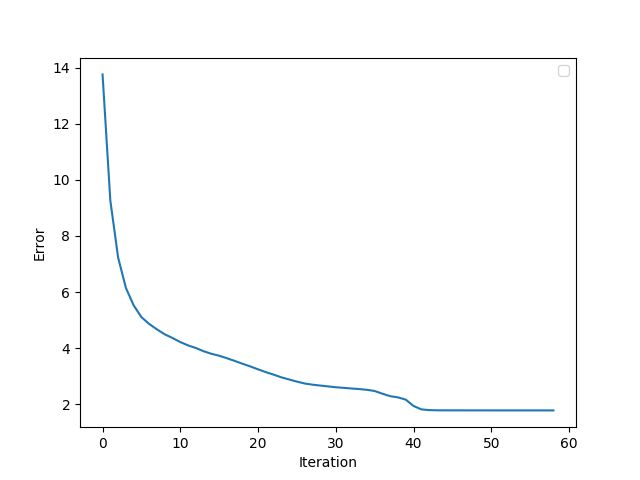
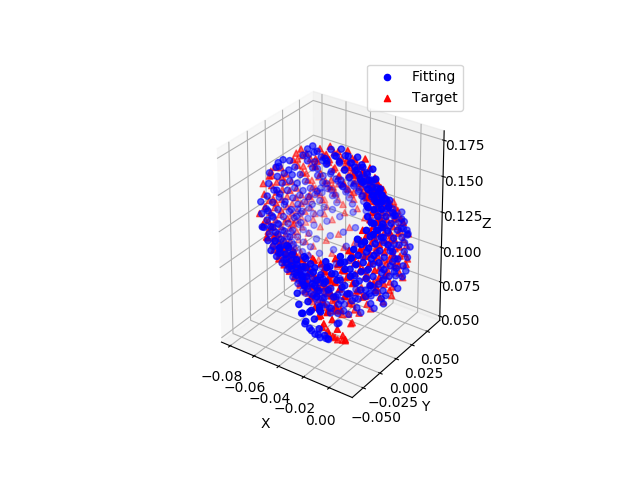
Target 0



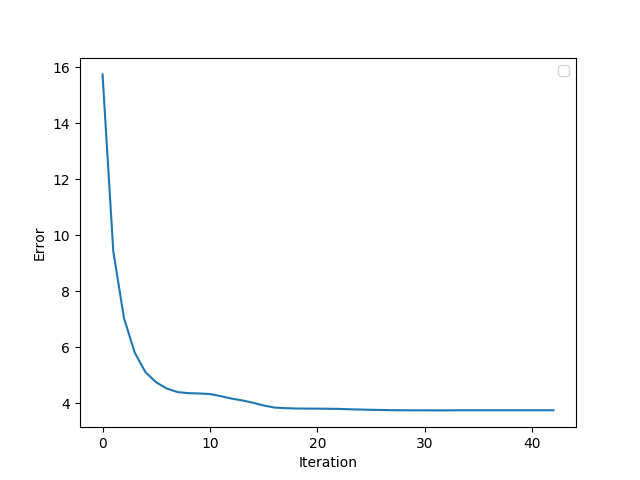
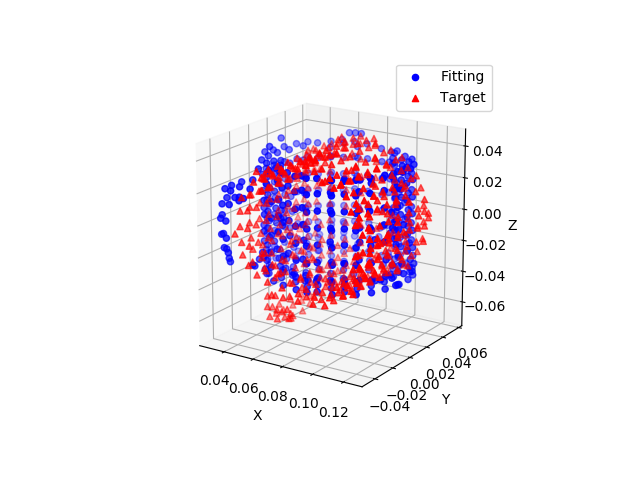
Target 1



Target 2



Target 3



Discussion