SLAM Assignment 3

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1 Iterative Closest Point

1.1

Differences between Point to Point ICP and Point to Plane ICP algorithm

When the point-to-plane error metric is used, the object of minimization is the sum of the squared distance between each source point and the tangent plane at its corresponding destination point.

In point to plane energy is given by the following equation :

$\sum(||(T_{gk} * V_k(u) - V^g{}_{k-1}(u)) * N^g{}_{k-1}(u)||)$

However, when the point-to-point error metric is used, the object of minimization is the sum of the squared distance between each source point and the destination point without the tangent plane.

Hence, In point to point energy is given by following
$\sum(||(T_{gk} * V_k(u) - V^g{}_{k-1}(u))||$

1.2

Equation 18 , give us :

Rotation and Translation Matrix = $\begin{bmatrix} [1, \alpha, -\gamma, t_x \\ -\alpha, 1, \beta, t_y \\ \gamma, -1 * \beta, 1, t_z] \end{bmatrix}$

Equation 19 gives us the x matrix :
x= $\begin{bmatrix} \beta, \gamma, \alpha, t_x, t_y, t_z \end{bmatrix}$

To proove :
R$^z * V^g{}_k(u) + t^z = G(u) * x + V^g{}_k(u)$;
Let V$^g{}_k(u) be [V_x, V_y, V_z, 1] (inhomogeneouscoordinatesystem)$

Using the Rotation matrix specified by equation 18 in eq 20 we get :

Hence substituting the value of Rotation and translation of eq 18 in eq 20 //

$$R^z * V^g{}_k(u) + t^z = \begin{bmatrix} [V_x + \alpha * V_y - \gamma * V_z + t_x \\ -\alpha * V_x + V_y + \beta * V_z + t_y \\ \gamma * V_x, -1 * \beta * V_y + V_z, t_z] \end{bmatrix}$$

The above equation can be rewritten as

$G(u)*x + V^g{}_k(u);$

Where x is given by equation 19 :

$$x = \begin{bmatrix} \beta, \gamma, \alpha, t_x, t_y, t_z \end{bmatrix}$$

Where G(u) is

$$G(u) = \begin{bmatrix} [0, -V_z, V_y \\ V_z, 0, -V_x \\ -V_y, V_x, 0] \end{bmatrix}$$

Where $V^g{}_k(u) is$

$V^g{}_k(u) = [V_x, V_y, V_z]$

Thus we have : $R^z * V^g{}_k(u) + t^z = G(u) * x + V^g{}_k(u)$

Also , transforming a point from one coordinate system to another involves use of Rotation and Translation between the coordinate frames . So :

$T_{gk}{}^z * V_k(u) = R^z * V^g{}_k(u) + t^z$

$Hence, equation 20 is proved$

1.3

The figures are placed at the end. Fig 18 -22 represnt the image for the ICP fusion.

2 POINT BASED FUSION

2.1

Other than the ability to handle dynamic objects easily, what are the advantages of point-based methods over volumetric methods with regular grids in general? (5 points)

Answer :

Point-based methods lower the memory overhead associated with volumetric (regular grid) approaches, as long as overlapping points are merged.
Point based methods are , therefore used in large sized reconstructions.

Point-based representations are more amenable to the input acquired from depth/range-sensors and reduce computation complexity.

2.2

3D point is given by : $\mathrm{p}^{'} = R * p + t$

where R and t are the rotation and translation respectively.

Correspond transformed normal should be :
$\mathrm{n}^{'} = R * p;$

Because vector transformations are not affected by Translation , thus only rotation component of the Transform should be considered.

Hence , there shall be no translation term.

2.3

Images of Point Based Fusion

3 Results And Discussion

3.1

Yes, it improves the registration, because the points in Fusion map would be more in number for calculating the ICP than the points in the current frame. This would mean better registration, as there may be a better neighbour of a point in fusion map than in the current frame. Thus, using Fusion map would improve the registration.

3.2

Since RMSE is the error in the registration or squared error of energies all matched points, the performance of point cloud registration increases as the RMSE decreases. Also, more number of Inliers indicates a better registration as a lot of points could be matched. So, performance of point cloud registration increases as Inliers increases

If the compress ratio is less , it would imply that more number of points are getting fused together and hence our model of mapping and tracking is more accurate. Hence, it can be said that Performance increases on decreasing the compress ratio but it should not be very low as it would prevent the scene from growing and we would not get a dense map. Therefore , it should be a reasonable number , depending on how many new points are infused in the map from one frame to the other frame.

3.3

Images for is$_eval()$

COUNTS : the ccounts for points in the left are more than the ccounts of the point in the right. as the color is brighter.

This is true because the camera moves from left to right and hence the points towards the left are seen in multiple frames , however the points towards the right are seen less. Therefore, the points towards the right are more dark.

NORMALS : As the blue line represents the normals. The normals at the couche are aligned very accurately. Also the normals at the floor and roof are aligned perpendicular to the surface. The normals at the wall are also nearly perpendicular to the surface.

TIMES : The time stamps of the points in the middle are more than the points in the extreme left and extreme right . The points in the middle appear in multiple points and hence are updated more often.

References

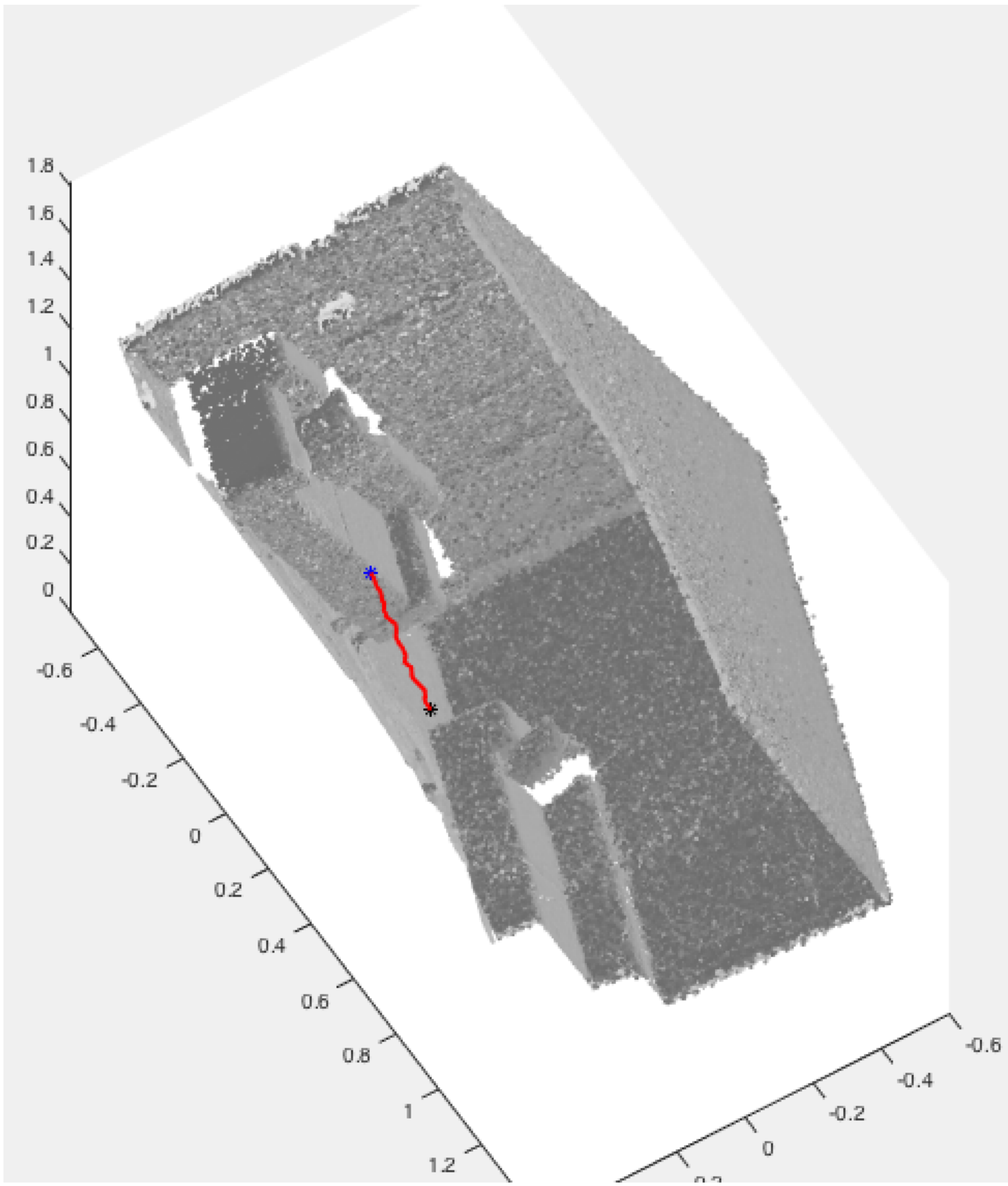

Figure 1: PointBasedFusion

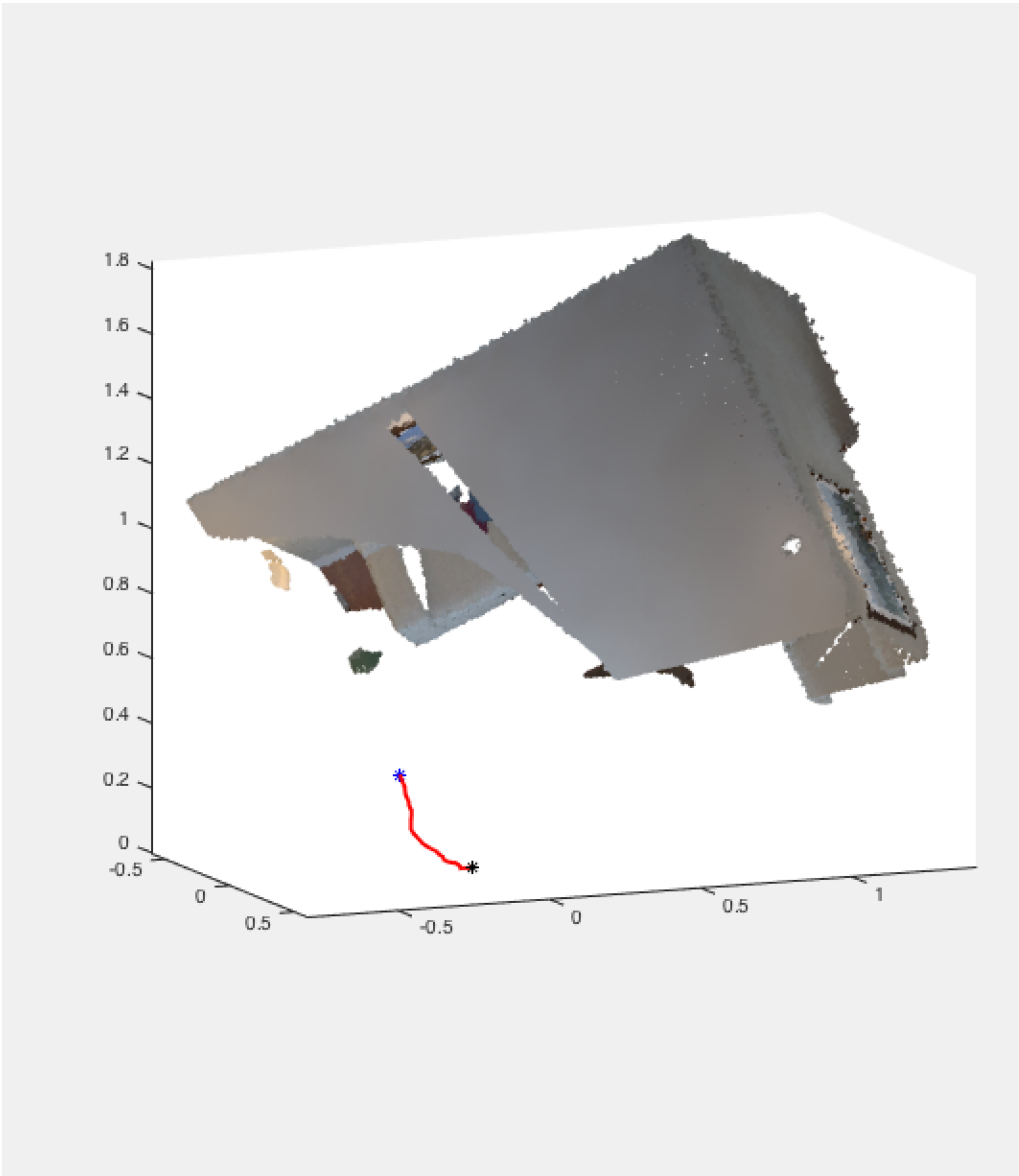

Figure 2: PointBasedFusion

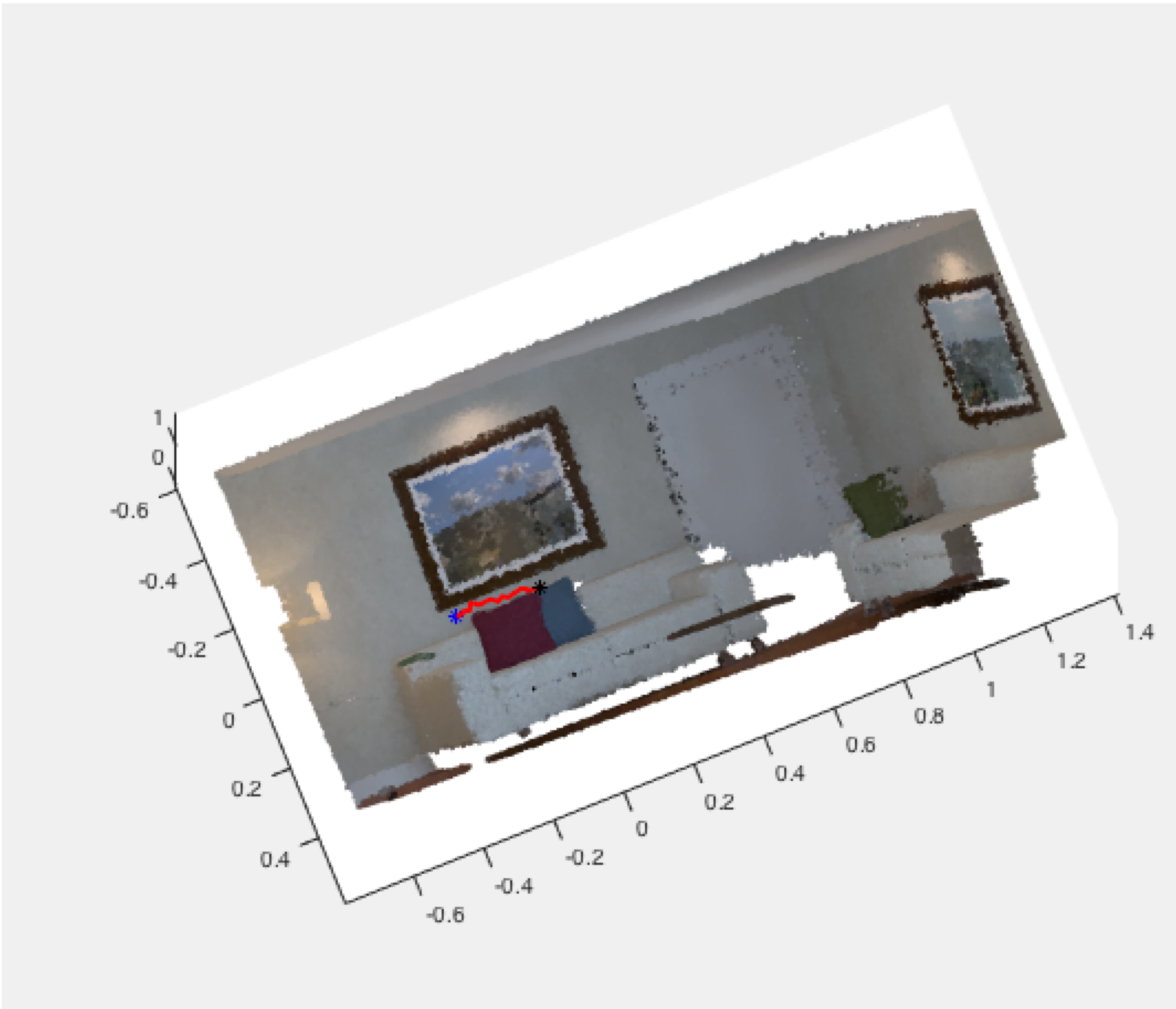

Figure 3: PointBasedFusion

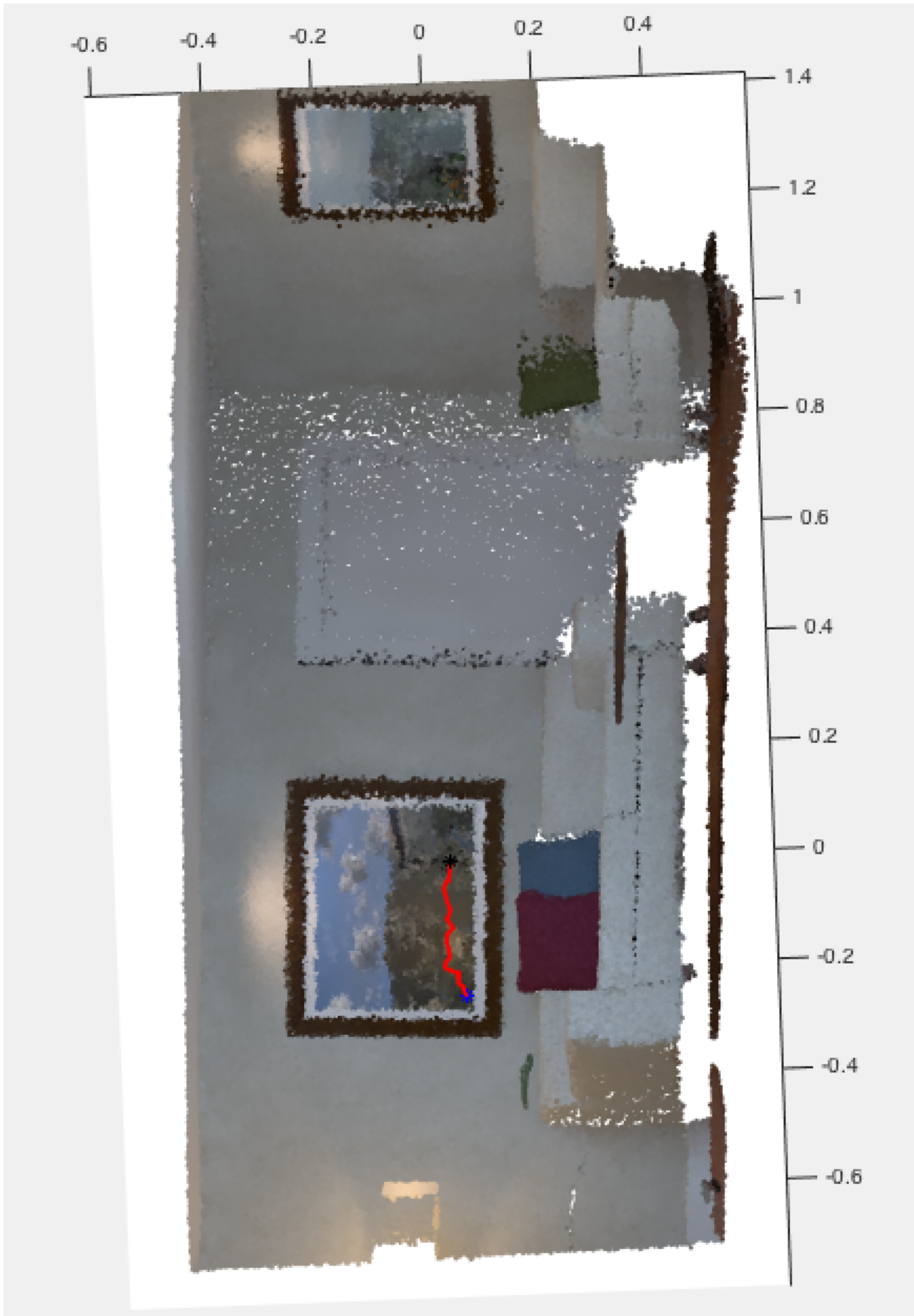

Figure 4: PointBasedFusion

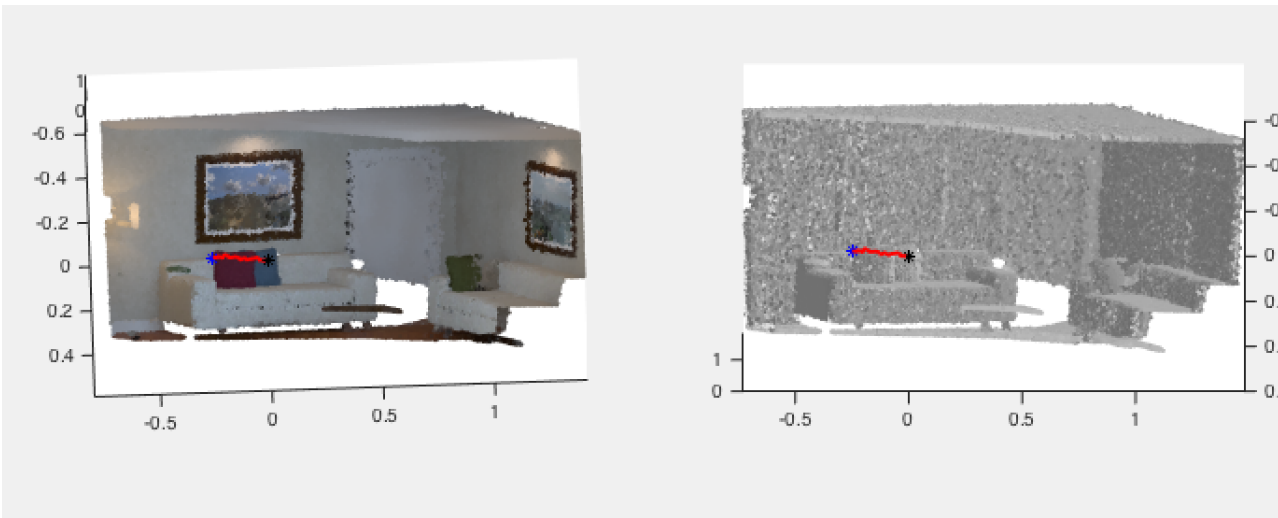

Figure 5: PointBasedFusion

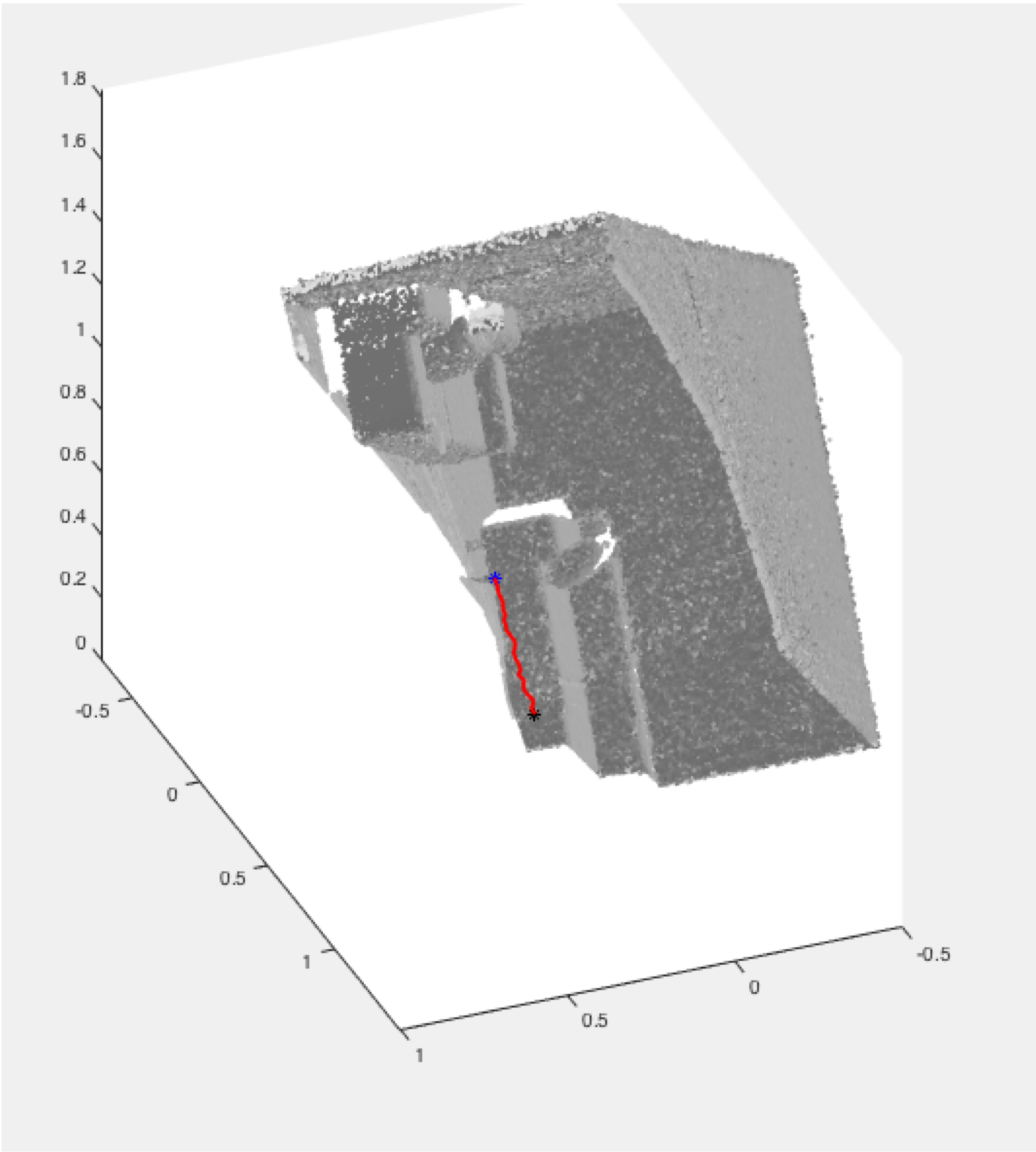

Figure 6: PointBasedFusion

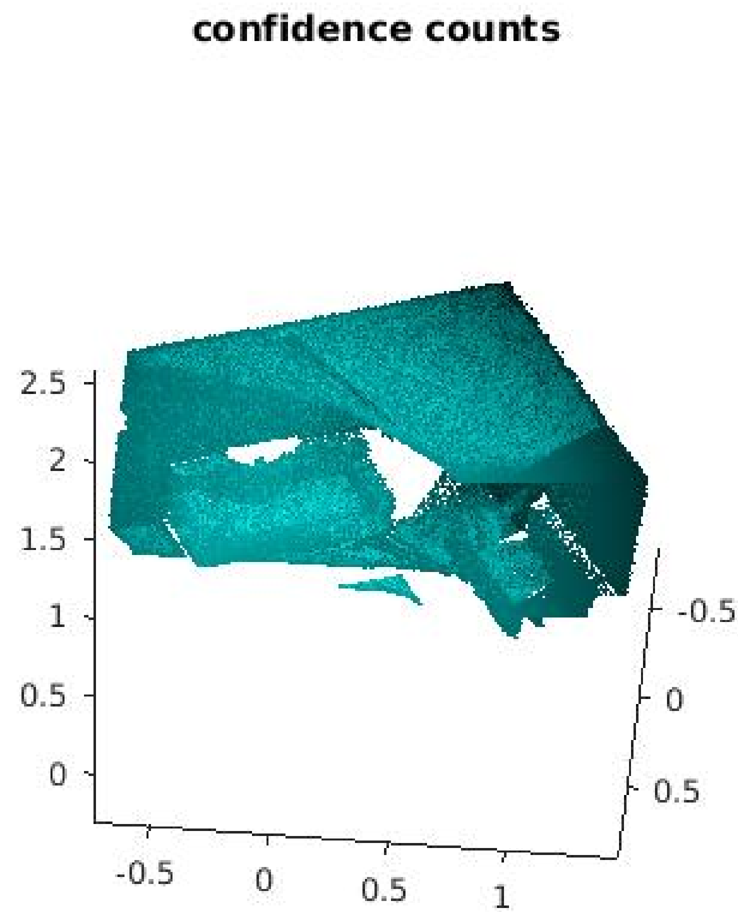

Figure 7: PointBasedFusion counts

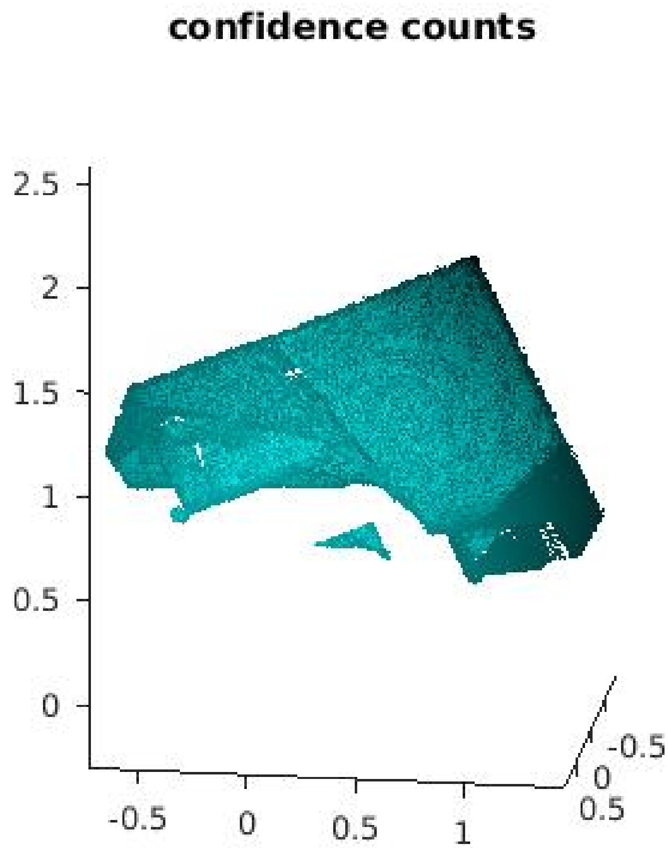

Figure 8: PointBasedFusion counts

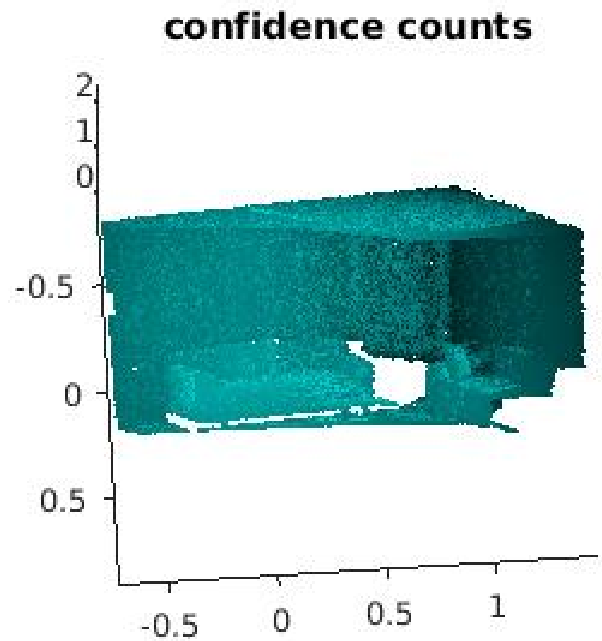

Figure 9: PointBasedFusion counts

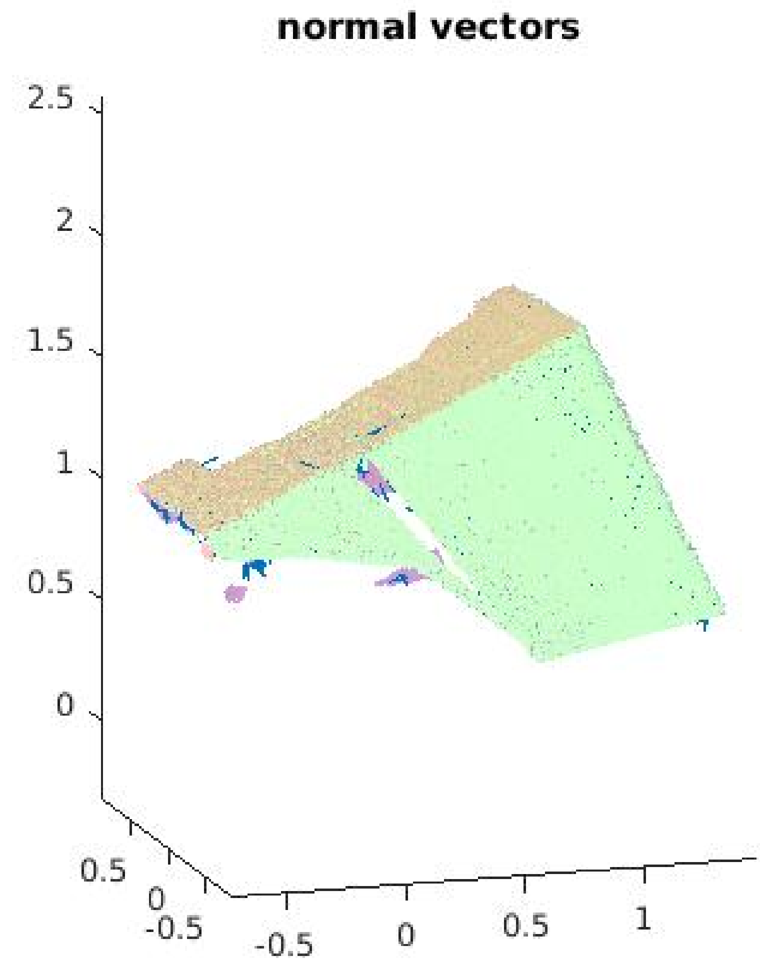

Figure 10: PointBasedFusion normals

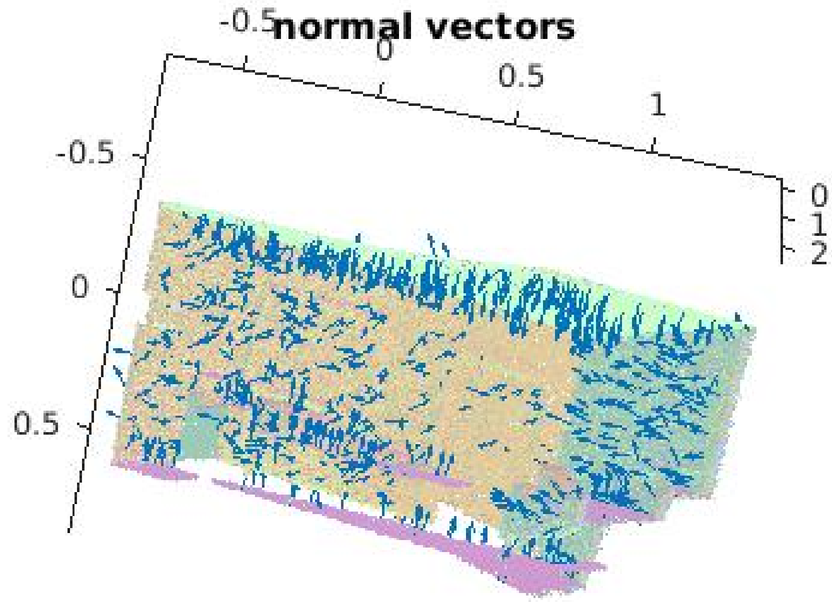

Figure 11: PointBasedFusion normals

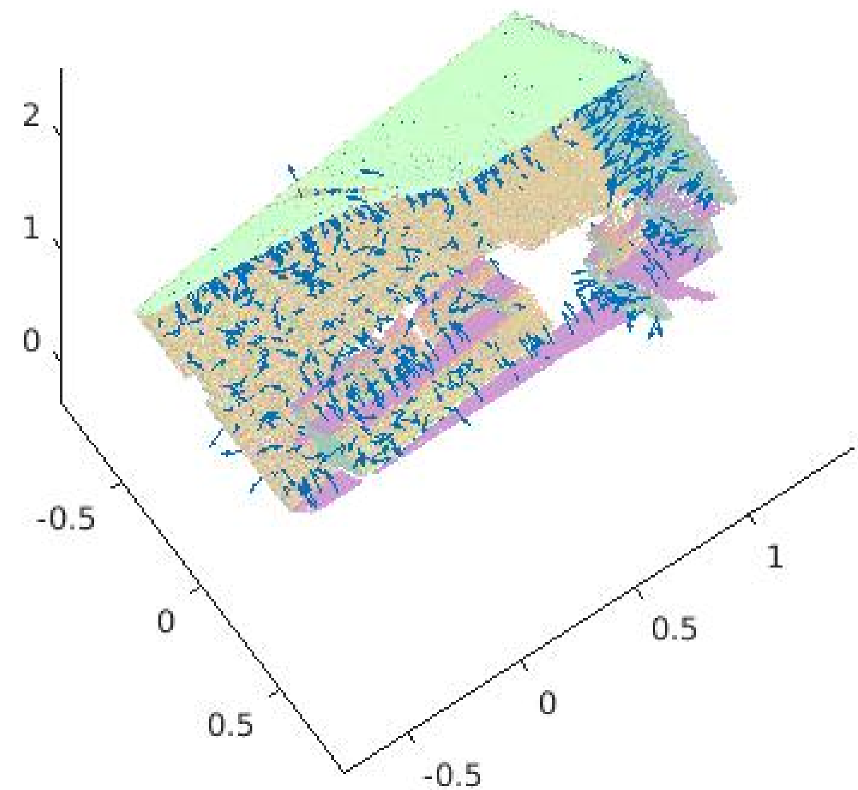

Figure 12: PointBasedFusion normals

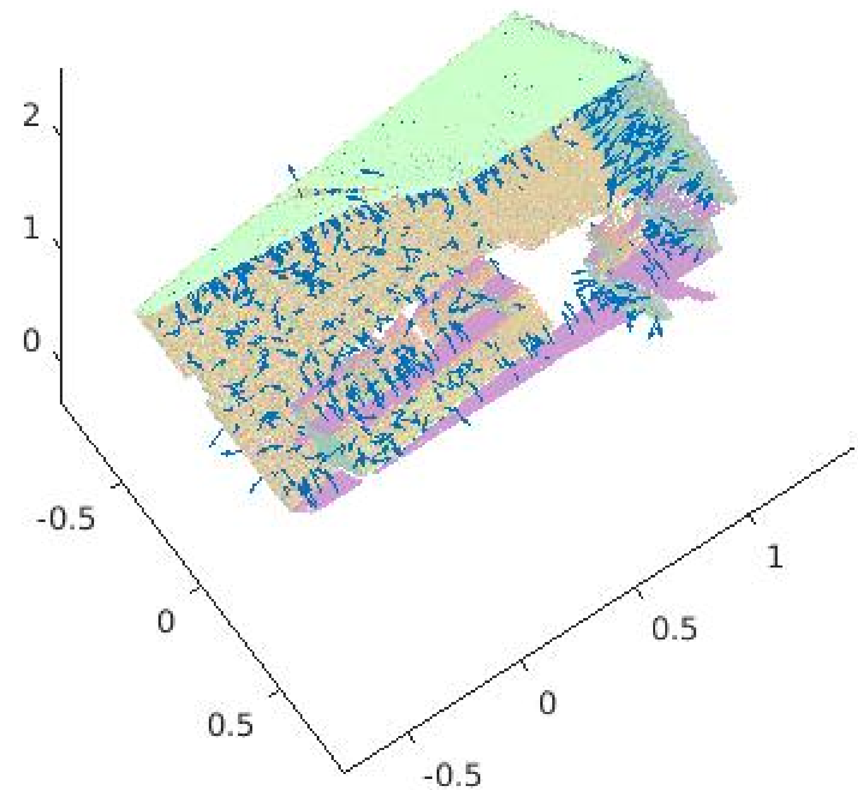

Figure 13: PointBasedFusion normals

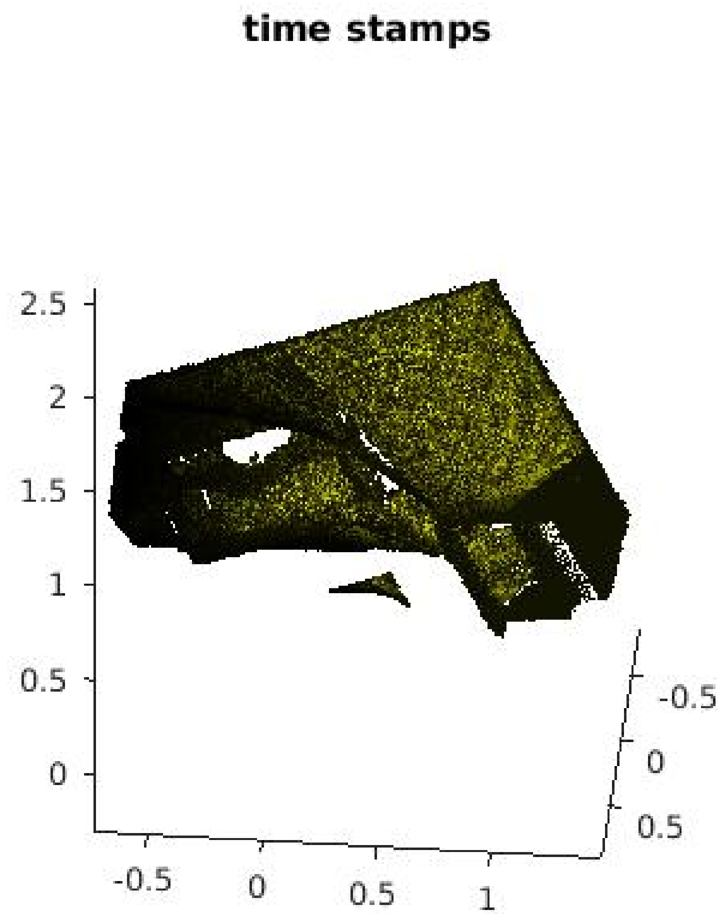

Figure 14: PointBasedFusion times

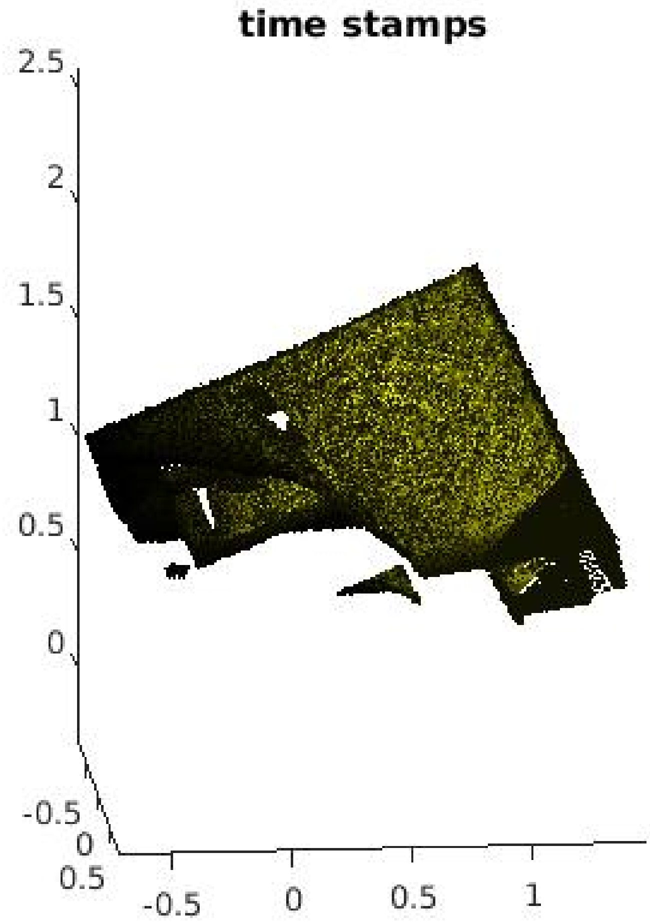

Figure 15: PointBasedFusion times

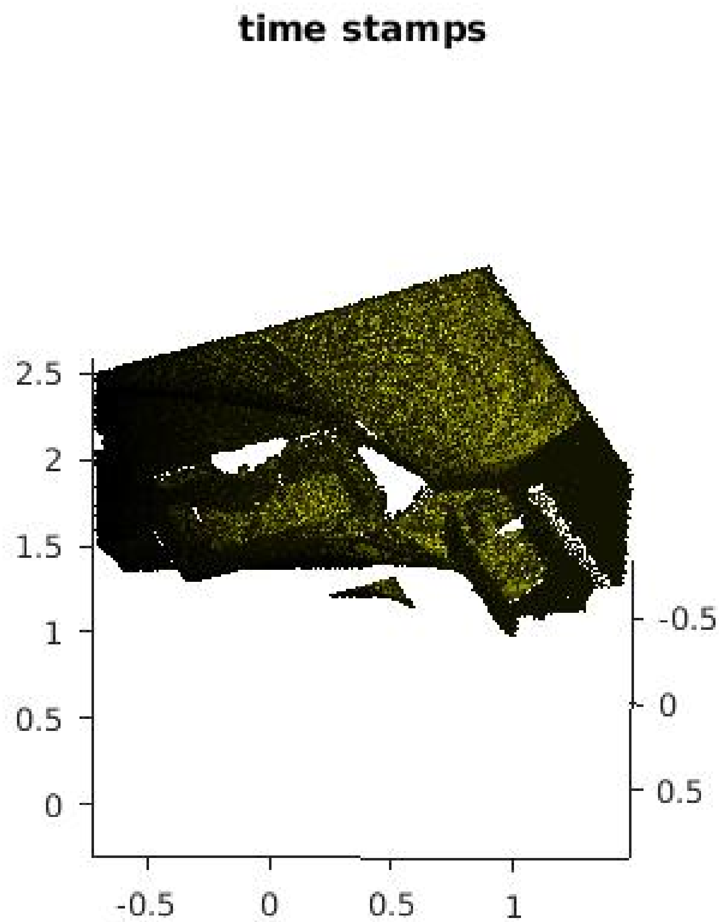

Figure 16: PointBasedFusion times

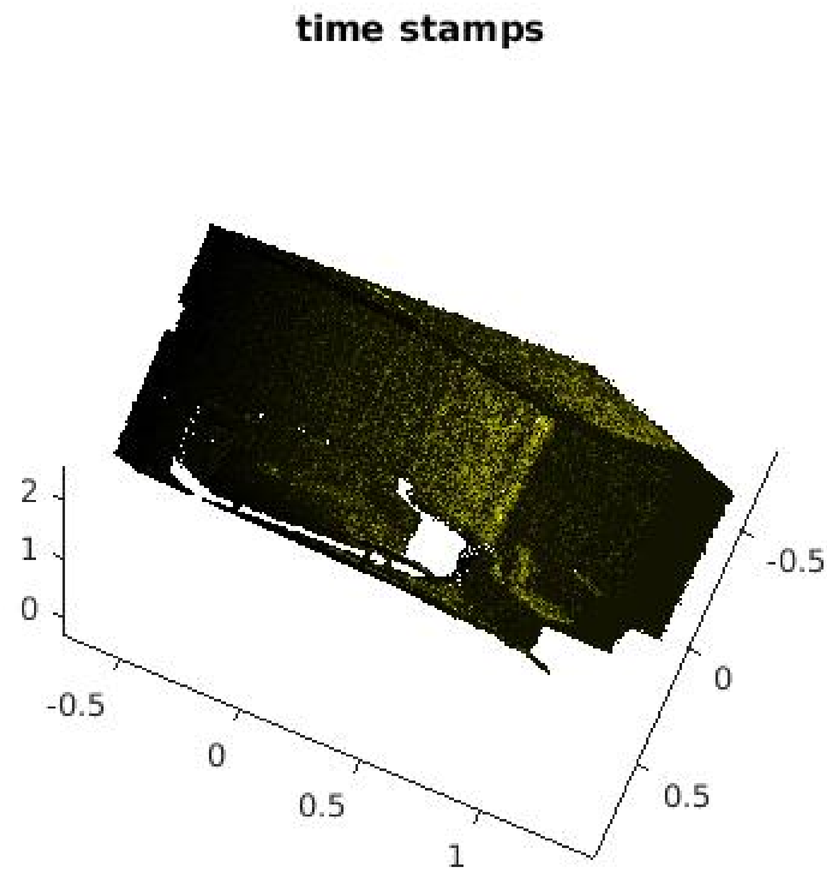

Figure 17: PointBasedFusion times

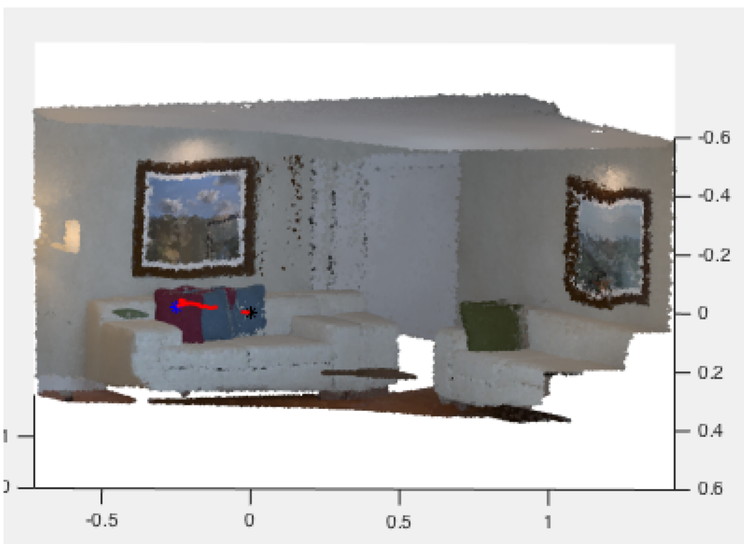

Figure 18: ICP VIEW 1

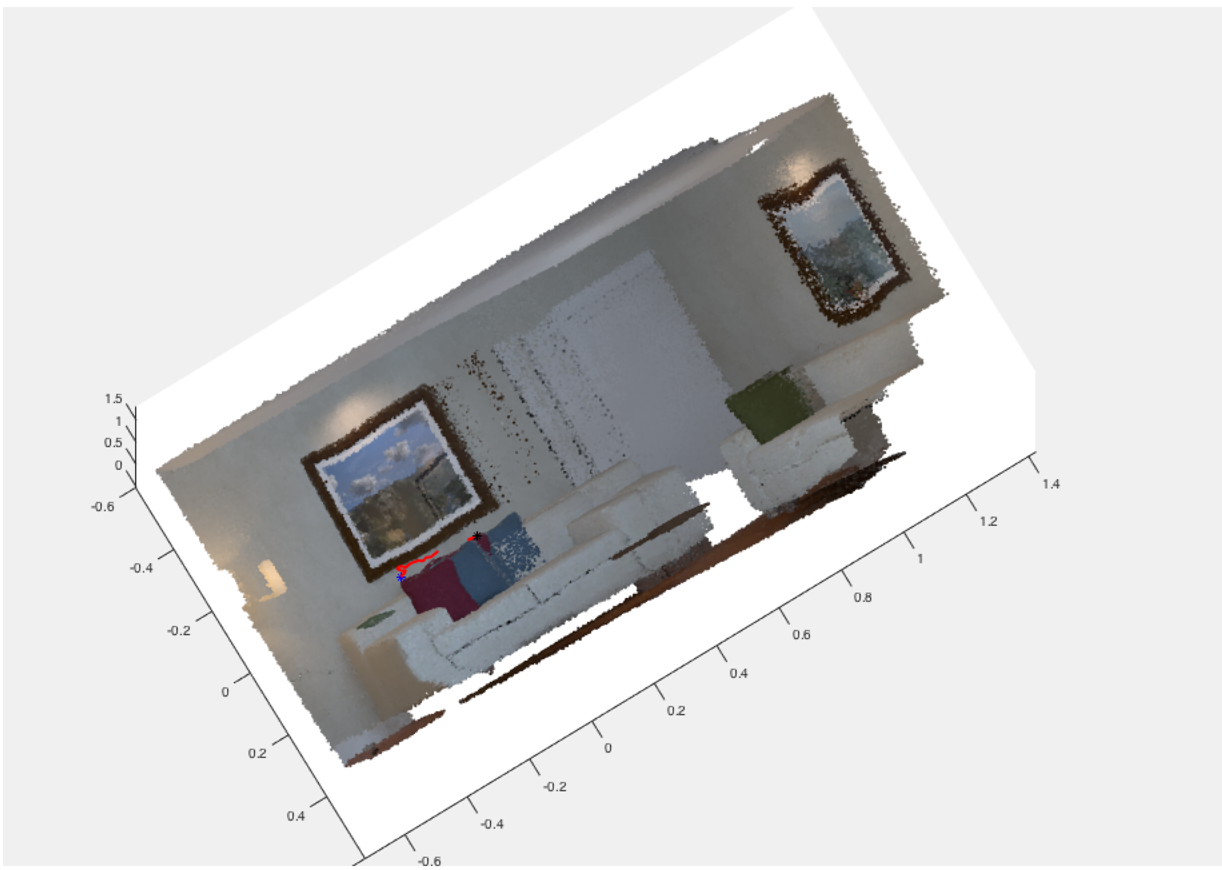

Figure 19: ICP VIEW 2

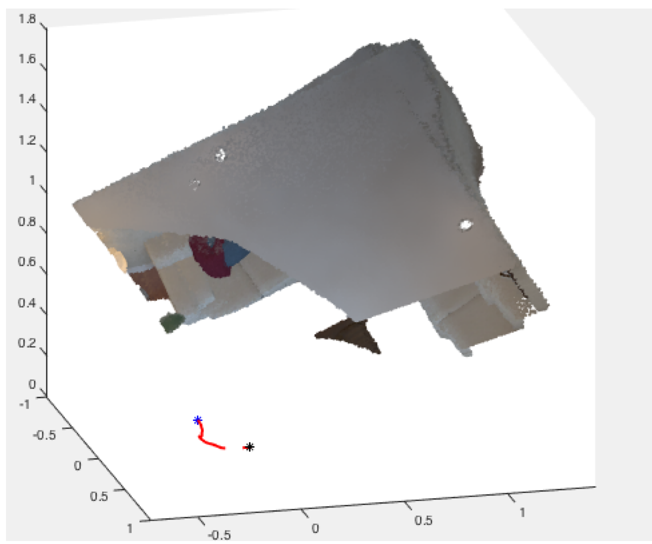

Figure 20: ICP VIEW 3

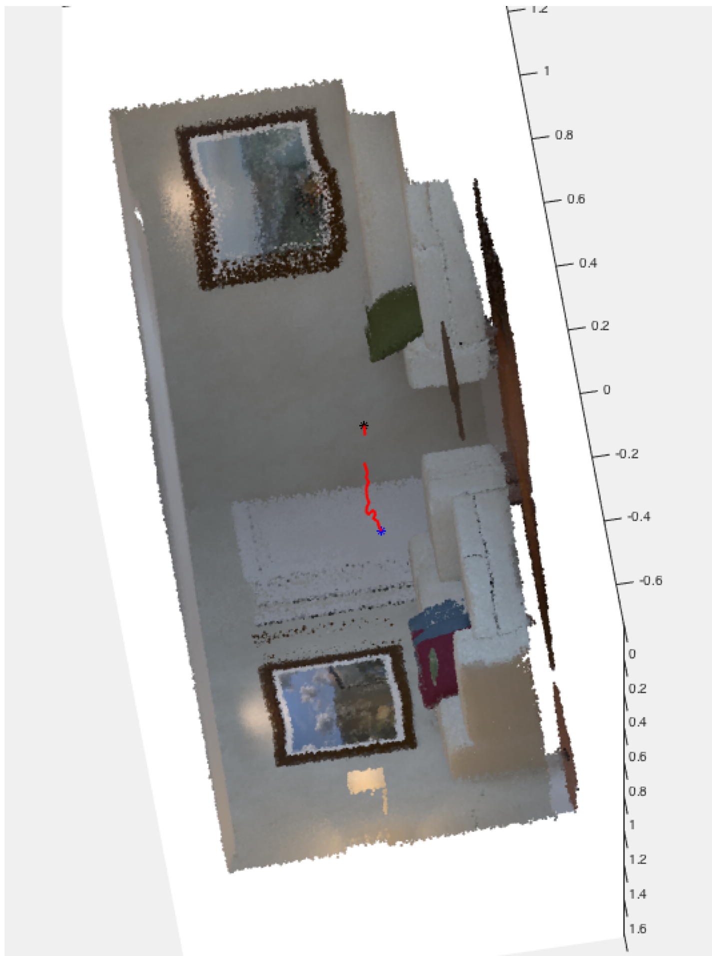

Figure 21: ICP VIEW 4

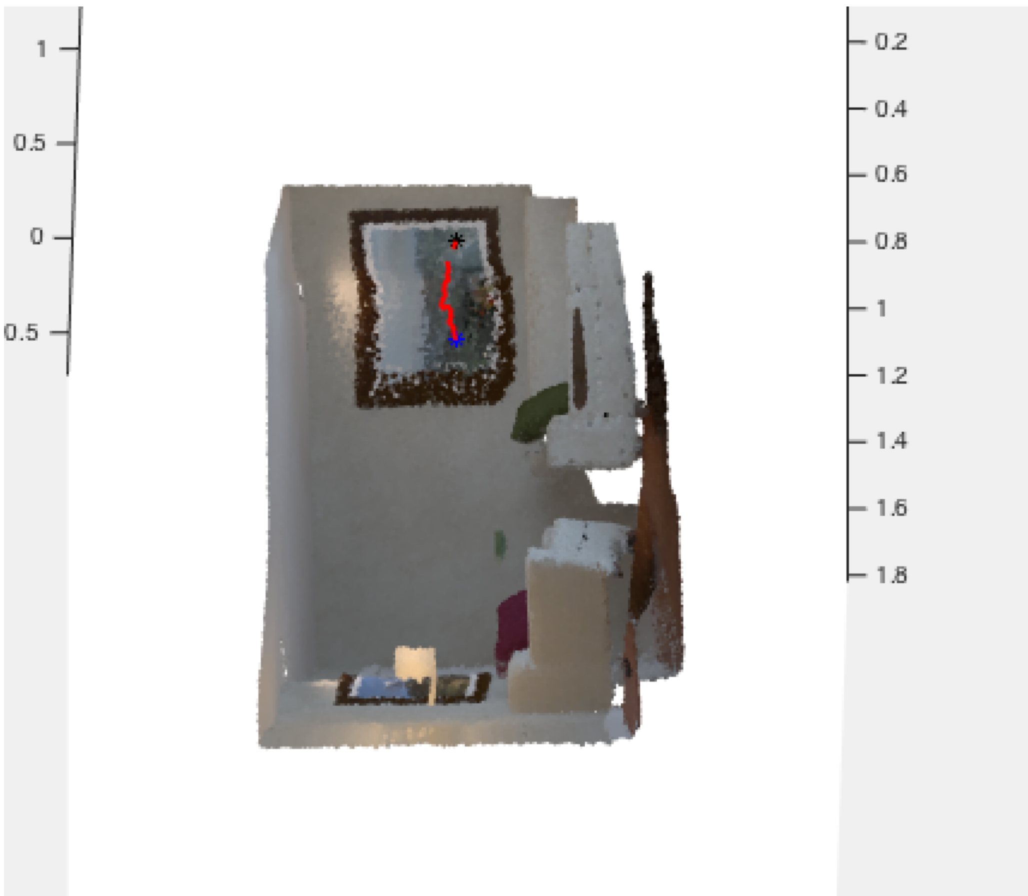

Figure 22: ICP VIEW 5