Dense SLAM with Point-based Fusion - Homework 4

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1 Overview

2 Iterative Closest Point

2.1 Projective data association

2.1.1

The conditions are:
$0 \le u < W$
$0 \le v < W$
$d > 0$

2.1.2

This step is necessary to remove all outliers, which prevents drift during the fusion process.

2.2 Linearization

$$\sum_{i\,=\,\Omega} \left(r_i^2\left(\delta R,\, \delta t\right)\right) = \left\|n_{q_i}^T\left(\left(\delta R\right)p_i' + \delta t - q_i\right)\right\|^2$$

The Right hand side can hence be written as:

$$\left\|\begin{pmatrix} n_{q_1} & n_{q_2} & n_{q_3} \end{pmatrix} \cdot \left(\begin{pmatrix} 1 & -\gamma & \beta \\ \gamma & 1 & -\alpha \\ -\beta & \alpha & 1 \end{pmatrix} \cdot \begin{pmatrix} p_1 \\ p_2 \\ p_3 \end{pmatrix} + \begin{pmatrix} t_x \\ t_y \\ t_z \end{pmatrix} - \begin{pmatrix} q_1 \\ q_2 \\ q_3 \end{pmatrix}\right)\right\|^2$$

Expanding this we get:

$$\begin{pmatrix} -n_{q_1}p_3 + n_{q_3}p_2 \\ n_{q_1}p_3 - n_{q_3}p_1 \\ -n_{q_1}p_2 + n_{q_2}p_1 \\ n_{q_1} \\ n_{q_2} \\ n_{q_3} \end{pmatrix}^T \cdot \begin{pmatrix} \alpha \\ \beta \\ \gamma \\ t_x \\ t_y \\ t_z \end{pmatrix} + n_{q_1}(p_1 - q_1) + n_{q_2}(p_2 - q_2) + n_{q_3}(p_3 - q_3)$$

Where $\begin{pmatrix} -n_{q_1}p_3 + n_{q_3}p_2 \\ n_{q_1}p_3 - n_{q_3}p_1 \\ -n_{q_1}p_2 + n_{q_2}p_1 \\ n_{q_1} \\ n_{q_2} \\ n_{q_3} \end{pmatrix}^T = A_i$ and

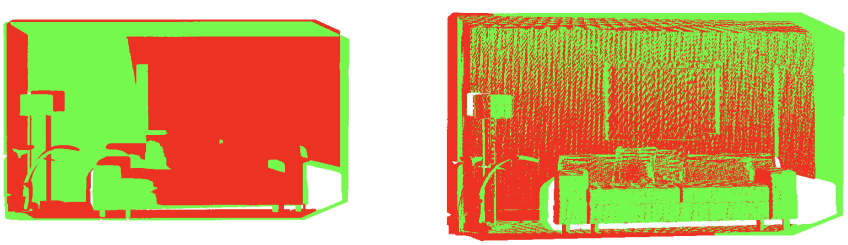
$n_{q_1}(p_1 - q_1) + n_{q_2}(p_2 - q_2) + n_{q_3}(p_3 - q_3) = b_i$

2.3 Optimization

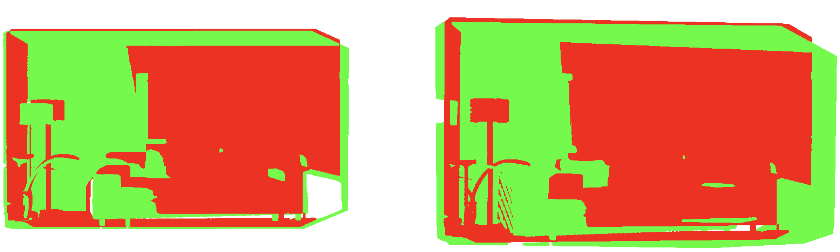
2.3.1

2.3.2

Frame 10 and 50



Frame 10 and 100



From the above figures it can be seen that the point cloud visualization between frames 10 and 50 are successful as can be observed by the increase in the number of features that are visible.
The visualizations between frames 10 and 100 is unsuccessful. This is because the distance between 10 and 50 is much smaller and as a result, the valid correspondences are more and the outliers are much less whereas the opposite is true for frames 10 and 100, where number of valid correspondences decrease because the range is so huge.

3 Point Based Fusion

3.1 Filter

3.2 Merge

The weighted average of positions(p) is:

$$p = \frac{(w \cdot p) + (R_c^{wq} + t_c^w)}{(w+1)} \tag{1}$$

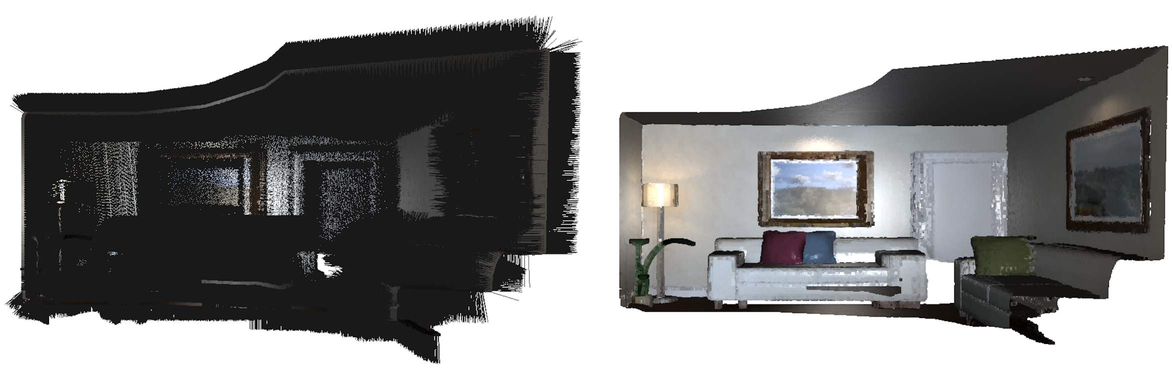
The weighted average of normals(n) is:

$$n = \frac{(w \cdot n_p) + (R_c^{wq} + n_q)}{(w+1)} \tag{2}$$

3.3 Addition

3.4 Results

Final Number of points in the map: 1362157
Compression Ratio: $1362157/(240 \times 320 \times 200) = 0.08868$
The visualizations can be seen in the below images:



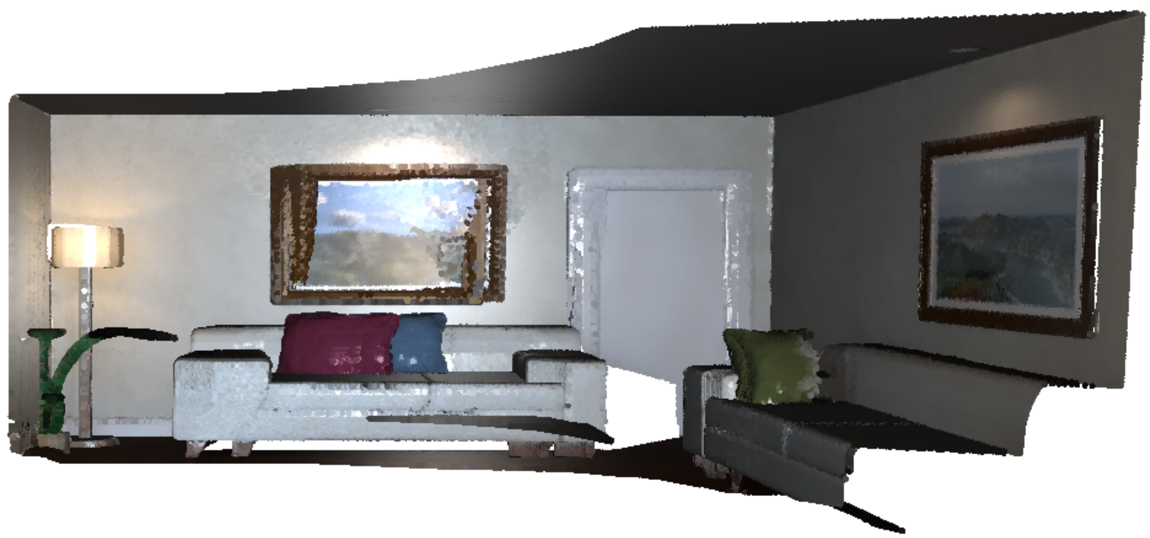
4 The dense SLAM system

4.1

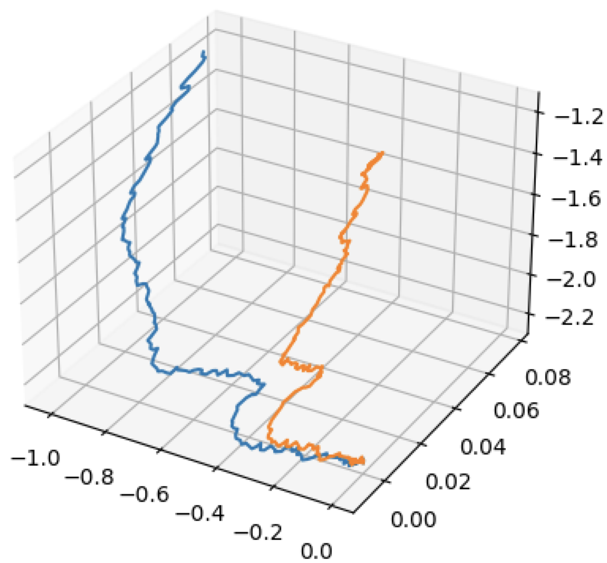
Source = Map points
Target = Current RGB-D frame
The roles cannot be swapped since the map points are projected onto a vertex map which is obtained from the current RGB-D frames and if the roles are swapped the lack of a vertex map would prevent the model from finding the corresponding points and outliers.

4.2

The visualization with fusion and ICP applied can be seen below:



The visualization for the trajectory can be seen in the figure below:



4.3 Bonus

5 Acknowledgements

I discussed this assignment with Yolnan Chen(yolnanc) and with Troy Vicsik(tvicsik)