1 Camera Calibration

1.1 Intrinsic Matrix

$$\begin{bmatrix} 509.51924844 & 0. & 310.07567526 \\ 0. & 511.4084455 & 194.70153536 \\ 0. & 0. & 1. \end{bmatrix}$$

1.2 Distortion Coefficient

$$\begin{bmatrix} 0.07328144 & -0.54115251 & -0.00178905 & 0.00203707 & 0.88329867 \end{bmatrix}$$

2 Feature Matching

In this assignment, I chose ORB to match features between two images (Figure 1). Compare to SIFT (Figure 2), ORB extracts less features for matching which might decrease the accuracy of the estimated trajectory but constructs the trajectory more than 80 time faster than SIFT as shown in Table 1.

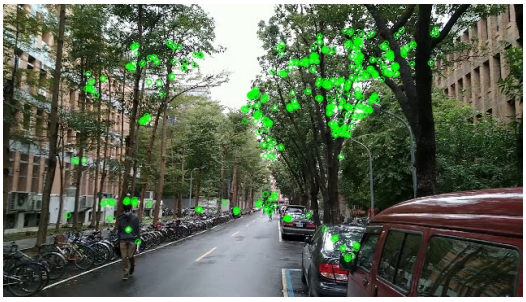

Figure 1: ORB Feature Points

Figure 2: SIFT Feature Points

Method	ORB	SIFT
Total Runtime (s)	92.47	7671.78

Table 1: Total Runtime of ORB and SIFT

3 Pose from Epipolar Geometry (pseudo codes and comments)

3.1 Finding Rotation and Translation

After finding the corresponding points of two adjacent images, these matching is helpful to calculate the essential matrix. Then essential matrix can be decomposed into rotation and translation by using features who are inliers.

Algorithm 1 Calculating rotation and translation

1: $des\_prev \leftarrow ORB\ descriptors\ for\ image_{t-1}$
2: $des\_curr \leftarrow ORB\ descriptors\ for\ image_t$
3: $matches \leftarrow the\ matches\ of\ desPrev\ and\ desCurr\ sorted\ by\ distance\ of\ each\ match$
4: $E \leftarrow the\ essential\ matrix\ from\ image_{t-1}\ to\ image_t$
5: $R \leftarrow the\ rotation\ from\ image_{t-1}\ to\ image_t\ calculated\ by\ feature\ inliers$
6: $t \leftarrow the\ translation\ from\ image_{t-1}\ to\ image_t\ calculated\ by\ feature\ inliers$

3.2 Scale Consistency

Find the same points(pixels) in ${}^{k}_{k-1}correspondence$ and ${}^{k+1}_{k}correspondence$ to calculate the scale factor of these points(pixels) matches. Then, calculate the median of these matches as the scale factor of relative pose.

Algorithm 2 Calculating scale factor

Require: $points_{t-1}$: Points in $image_{t-1}$
$points_t$: Points in $image_t$
X_{t-1} : Triangulated points in $image_{t-1}$
X_t : Triangulated points in $image_t$
Ensure: $scale\_factor$: Scale factor of $image_{t-1}$ and $image_t$

```
for each point_t ∈ points_t do
    for each point_{t-1} ∈ points_{t-1} do
        if point_t = point_{t-1} then add point_t and point_{t-1} into matches
        end if
    end for
end for
if only has one match then return 1
end if
for each match in matches do
    compute scale factor of each match
end for
return median of scale factors
```

4 Results Visualization

As discussed above, ORB extracts less feature points than SIFT, which make the trajectory estimated by ORB (Figure 3) looks slightly worse than that estimated by SIFT (Figure 4). However, considering the total runtime, ORB is still a more favorable choice. The video can be watched in https://youtu.be/zbmFC2vT0jM .

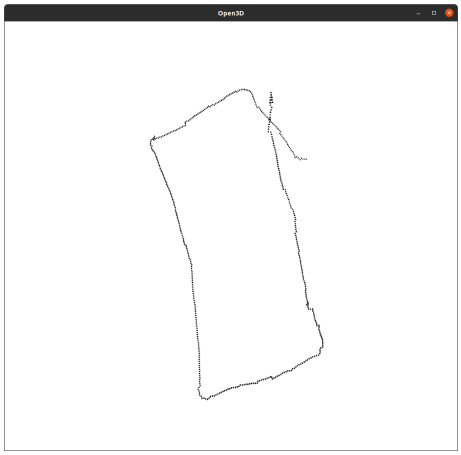

Figure 3: Trajectory estimated by ORB

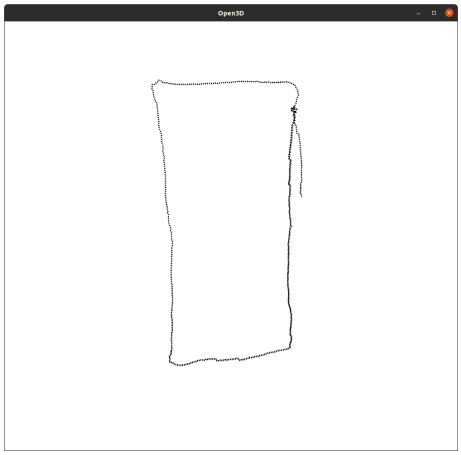

Figure 4: Trajectory estimated by SIFT