CSCI 5980 Assignment 3

Download the codes for the assignment here.
https://drive.google.com/open?id=1Q7kmNDrfMu_h8g0_uZLQTZT2tV51DGn_

1 Camera Calibration

The ground-truth intrinsic matrix of the camera is

$$\mathbf{K} = \begin{bmatrix} f & 0 & p_x \\ 0 & f & p_y \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 3351.6 & 0 & 2016 \\ 0 & 3351.6 & 1512 \\ 0 & 0 & 1 \end{bmatrix}$$

Using Single Image Calibration, the result of the intrinsic matrix is

$$\mathbf{K} = \begin{bmatrix} 3270.8 & 0 & 2043 \\ 0 & 3270.8 & 1561 \\ 0 & 0 & 1 \end{bmatrix} \tag{1}$$

Using Multiple Image Calibration with 6 images, the result of the intrinsic matrix is

$$\mathbf{K} = \begin{bmatrix} 3394.6 & 0 & 1992.2 \\ 0 & 3394.6 & 1464.8 \\ 0 & 0 & 1 \end{bmatrix} \tag{2}$$

Using MATLAB Calibration Toolbox with 20 images, where the camera poses are shown in Fig. 1, the result of the intrinsic matrix is

$$\mathbf{K} = \begin{bmatrix} 3383.35 & 0 & 1999.71 \\ 0 & 3383.35 & 1474.78 \\ 0 & 0 & 1 \end{bmatrix} \tag{3}$$

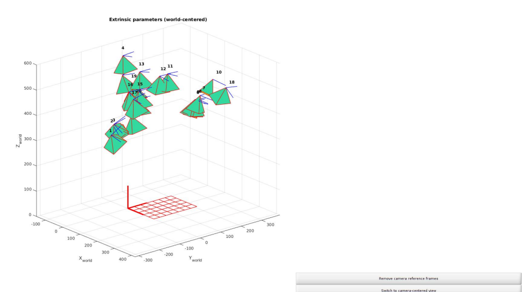


Figure 1: Extrinsic parameters

and the fourth order distortion parameters are given as

$$k_c = \begin{bmatrix} 0.28024 & -1.21994 & -0.00084 & -0.00272 \end{bmatrix} \tag{4}$$

2 Rotation Interpolation

Given two images of pure rotation, we first compute the homography between two images ${}^{R}\mathbf{H}_L$ using correspondences, then the rotation matrix is

$$ {}^{R}\mathbf{R}_L = \mathbf{K}^{-1}{}^{R}\mathbf{H}_L\mathbf{K} \tag{5} $$

Next we interpolate between two rotations from the left image (quaternion q_1) to the right image (quaternion q_2) using SLERP

$$ p = \frac{q_1 \sin{(1-w)\Omega} + q_2 \sin{(w\Omega)}}{\sin\Omega} \tag{6} $$

and convert interpolated quaternion to rotation matrix ${}^{i}\mathbf{R}_L$ $(i = 1, ..., N)$ where N is the number of interpolated rotations. Then the homography between iamges are computed as follows

$$ {}^{i}\mathbf{H}_L = \mathbf{K}{}^{i}\mathbf{R}_L\mathbf{K}^{-1} \tag{7} $$

$$ {}^{i}\mathbf{H}_R =^{i} \mathbf{H}_L {}^{R}\mathbf{H}_L{}^{-1} \tag{8} $$

With the homographies, we can map the left and right image to the target one and combine them together and thus we genrate a sequence of views by interpolating between rotations, as shown in Fig. 2.

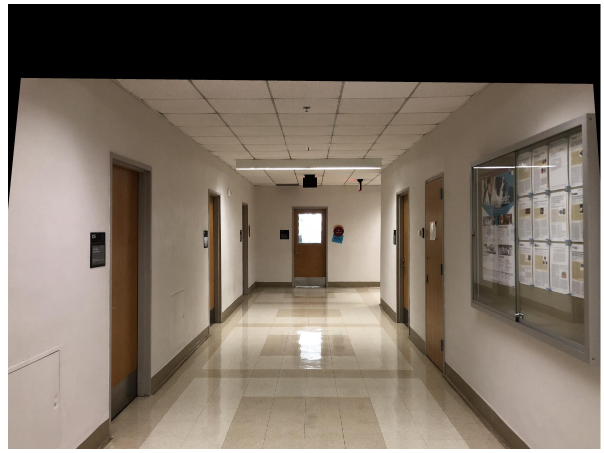
Figure 2: Interpolated view by sampling rotation

3 Tour into Your Picture

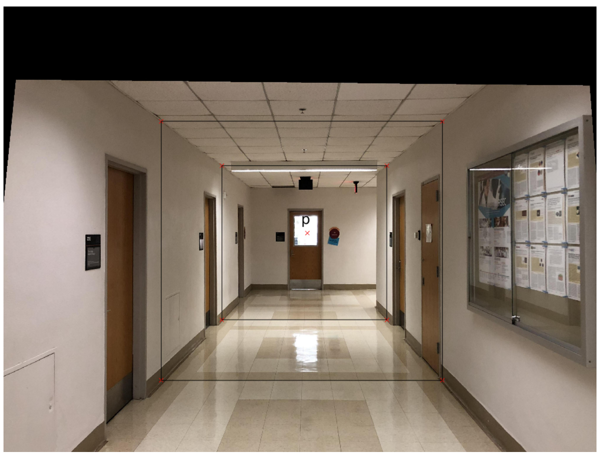
We first take a photo with the cellphone camera of second floor in the Smith Hall, then rectify it with the gravity, and compute the vanish point, as shown in Fig. 3a,3b,3c. Then we use a 3D box to represent the scene, as visualized in Fig. 3d. We can make the camera move to generate the new view, as shown in Fig. 3e, 3f. We can also generate a video of navigation by interpolating rotation and translation.

We have to skip the details of the above question due to the page limit, while one useful trick can be emphasized here. In the mapping from the original image (the rectified image), we need to somehow "crop" the five planes and map them via the individual homography respectively. While the plane in the original image might not be a rectangle and hard to deal with. the Instead of cropping the plane out on the orginal image, we can first convert the plane into a rectangle and then map the rectangle into the target iamge. The idea is that each plane is a rectangle in 3D space though their 2D view might not.

(a) Source image

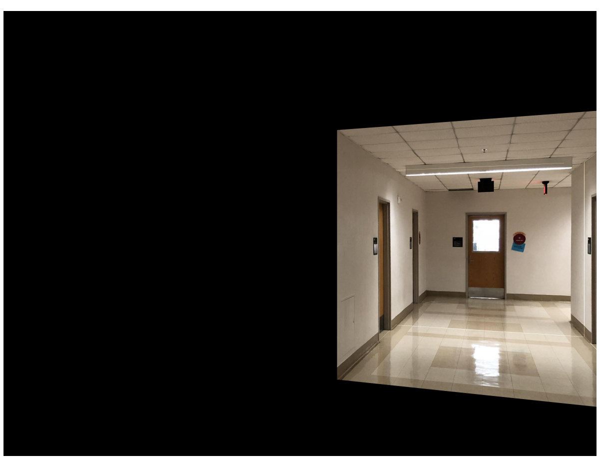


(b) Rectified image

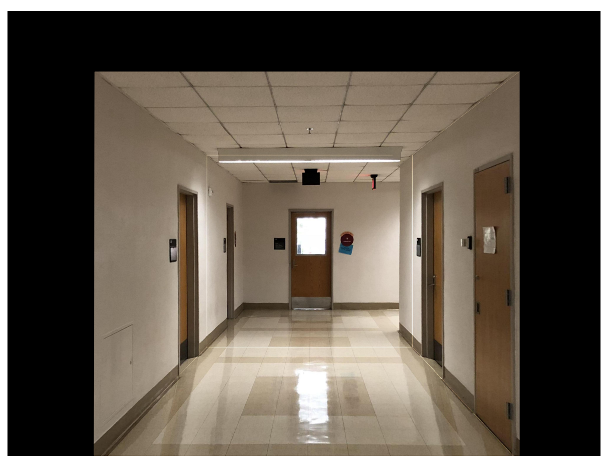


(c) Vanishing point

(d) 3D reconstruction



(e) Camera pitch with 20 degrees



(f) Camera displacement with 0.2*d

Figure 3: Figures of question 2