Computer Vision Homework 3

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1. RGB and IR Camera Calibration [20 pts]

The intrinsic calibration matrix of the IR camera.

$$\mathcal{K}_{IR} = \begin{bmatrix} 611.4 & 0 & 343.3 \\ 0 & 625.9 & 251.1 \\ 0 & 0 & 1 \end{bmatrix}$$

The intrinsic calibration matrix of the RGB camera.

$$\mathcal{K}_{RGB} = \begin{bmatrix} 534.0 & 0 & 319.5 \\ 0 & 533.7 & 239.5 \\ 0 & 0 & 1 \end{bmatrix}$$

Average re-projection error. Average re-projection error of IR camera: [2.08781, 2.06990].
Average re-projection error of RGB camera: [0.24257 0.25948].

2. Stereo Camera Calibration [20 pts]

New intrinsic calibration matrices.

$$\hat{\mathcal{K}}_{IR} = \begin{bmatrix} 617.7 & 0 & 331.0 \\ 0 & 629.0 & 233.5 \\ 0 & 0 & 1 \end{bmatrix}$$

$$\hat{\mathcal{K}}_{RGB} = \begin{bmatrix} 526.0 & 0 & 319.5 \\ 0 & 539.3 & 239.5 \\ 0 & 0 & 1 \end{bmatrix}$$

The stereo calibration parameters.

$$\boldsymbol{R} = \begin{bmatrix} 0.9998 & -0.0042 & 0.0208 \\ 0.0041 & 1.0000 & 0.0050 \\ -0.0208 & -0.0049 & 0.9998 \end{bmatrix}$$

$$\boldsymbol{T} = \begin{bmatrix} 24.73086 \\ -7.80400 \\ -32.76554 \end{bmatrix}$$

Note that the unit of $\boldsymbol{T}$ here is mm. Consider divide $\boldsymbol{T}$ by $1,000$ if the unit of the coordinates is m.

The stereo result. Calib_Results_stereo.mat contains the stereo calibration results from the toolbox.

3. Colored 3D Point Cloud [60 pts]

3.1. Compute the 3D coordinates of points

For each pixel $\boldsymbol{x}_{IR}$ in the depth image with pixel value $\boldsymbol{I}_D(\boldsymbol{x}_{IR})$, its corresponding 3D coordinates in the IR camera coordinate system can be calculated by:

$$\boldsymbol{X} = \boldsymbol{I}_D(\boldsymbol{x}_{IR})\,\hat{\mathcal{K}}_{IR}^{-1}\begin{bmatrix} \boldsymbol{x}_{IR} \\ 1 \end{bmatrix} \tag{1}$$

where $\hat{\mathcal{K}}_{IR}$ is the intrinsic calibration matrix for IR camera.

With the help of MATLAB, Equation 1 can be implemented in the format of matrix multiplication. The 3D coordinates for all pixels can be calculated efficiently using just one line. The reconstructed point clouds is shown in Figure 1. The reconstruction quality is good enough. The color is the default color by MATLAB, not the real color of the material.

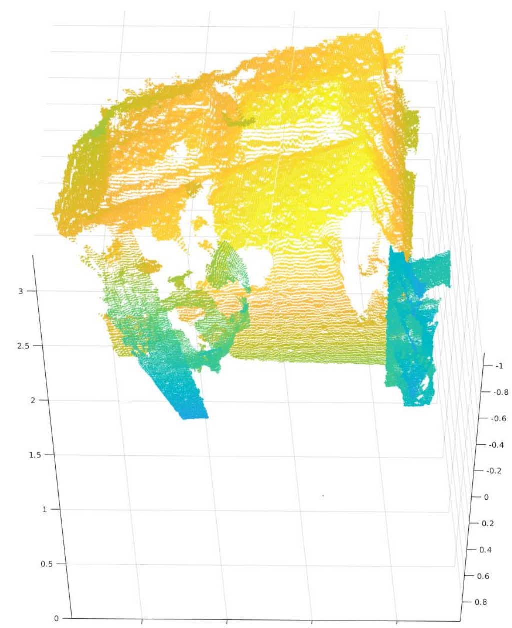

Figure 1: **The reconstructed point clouds from the Depth map only.** The color here is the default color by MATLAB.

3.2. Backproject point cloud to image plane

Take the one point $\boldsymbol{X}$ in a given point cloud, the corresponding pixel coordinate in the image plane can be calculated by:

$$\hat{\boldsymbol{x}}_{RGB} = \hat{\mathcal{K}}_{RGB}[\boldsymbol{R} \quad \boldsymbol{T}] \begin{bmatrix} \boldsymbol{X} \\ 1 \end{bmatrix} \tag{2}$$

where $\hat{\mathcal{K}}_{RGB}$ is the intrinsic calibration matrix for the RGB camera. $\boldsymbol{R}$ and $\boldsymbol{T}$ is the rotation and translation matrix from the IR camera to the RGB camera, respectively.

3.3. 3D colored point cloud

Figure 2 shows the colored point cloud at different views using Meshlab.

3.4. New extrinsic parameters

The resulting virtual camera RGB image is shown in Figure 3.

All codes are available at attached main.m file.

Figure 2: **Colored 3d point clouds from different viewpoints.**

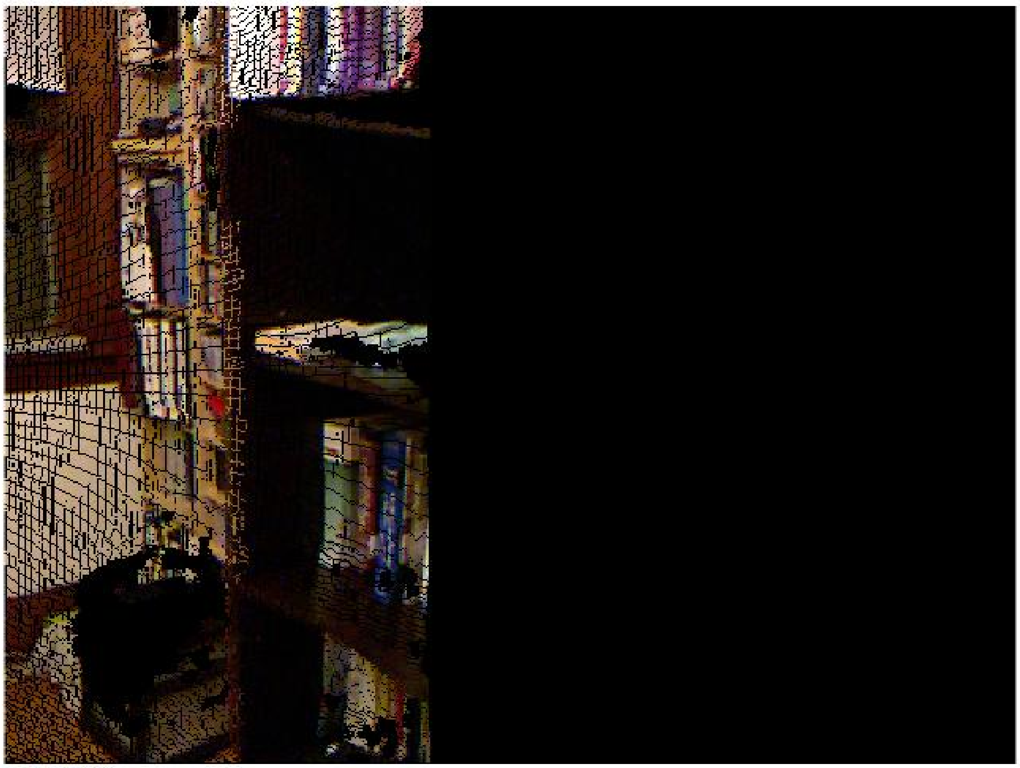

Figure 3: **Virtual camera RGB image.**