3-D Computer Vision
Homework 1

Ning Zhang

September 21, 2017

Problem 1

In the part of projective transformation, the coordinates of the four court corners in the image: bottom left: $[24, 194]$; bottom right: $[280, 280]$; top left: $[249, 51]$; top right: $[404, 74]$.

By SVD, We obtain the homography matrix H:

$$H = \begin{bmatrix} 0.0011 & -0.0034 & 0.6349 \\ 0.0023 & 0.0037 & -0.7726 \\ 0.0000 & 0.0000 & 0.0006 \end{bmatrix}$$

In the part of bilinear interpolation, the interpolation strategy is as follows. For each blank pixel in the new image, its neighbors from eight directions are chosen, and among non-blank neighbors the average value of each color channel is calculated and assigned to the target pixel. For marginal lines of pixels, they are filled by copying neighboring line of pixels.

Problem 2

In order to create dolly zoom, we need to simultaneously adjust the focal length as the camera moves towards or away from the target object.

Now we have extrinsic matrix at time i as follows.

$$[R|t] = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & c * i \end{bmatrix}$$

, where c is distance offset on the axis of Z for each time step.

And camera intrinsic matrix:

$$K = \begin{bmatrix} f_x & 0 & p_x \\ 0 & f_y & p_y \\ 0 & 0 & 1 \end{bmatrix}$$

, With that being listed, we can assume that a point p in the target object has coordinates of $[X, Y, Z, 1]$ in the homogeneous world frame, and its projected point p_{cam} at time step i has coordinates $[x, y, 1]$ in the camera frame after extrinsic and intrinsic transformation as follows.

$$p_{cam,i} = K[R|t_i]p$$

at time step $i + 1$,

$$p_{cam,i+1} = K[R|t_{i+1}]p$$

Using the fact that the size of the target object is constant in the image throughout the whole process of dolly zoom, here $p_{cam,i} = p_{cam,i+1}$, such that

$$x_i = xi + 1$$

$$y_i = yi + 1$$

After expanding matrices in the equations above, we have the following equations.

$$x = \frac{Xf_{x,i} + Zp_x + p_x ct_i}{Z + ct_i} = \frac{Xf_{x,i+1} + Zp_x + p_x ct_{i+1}}{Z + ct_{i+1}}$$

$$y = \frac{Yf_{y,i} + Zp_y + p_y ct_i}{Z + ct_i} = \frac{Yf_{y,i+1} + Zp_y + p_y ct_{i+1}}{Z + ct_{i+1}}$$

By solving equations for $f_{x,i+1}$ and $f_{y,i+1}$, we get the following equations.

$$f_{x,i+1} = \frac{Z + ct_{i+1}}{Z + ct_i} f_{x,i}$$

$$f_{y,i+1} = \frac{Z + ct_{i+1}}{Z + ct_i} f_{y,i}$$

By updating the camera intrinsic matrix with new focal lengths, we can achieve the dolly zoom effect. For details, please see attached codes.