ENGN4528 Computer Vision – 2021
Computer-Lab 3 (C-Lab3)

Hongxiang Zhang(u7101924)
[1]Australian National University

May 20, 2021

1 Task-1

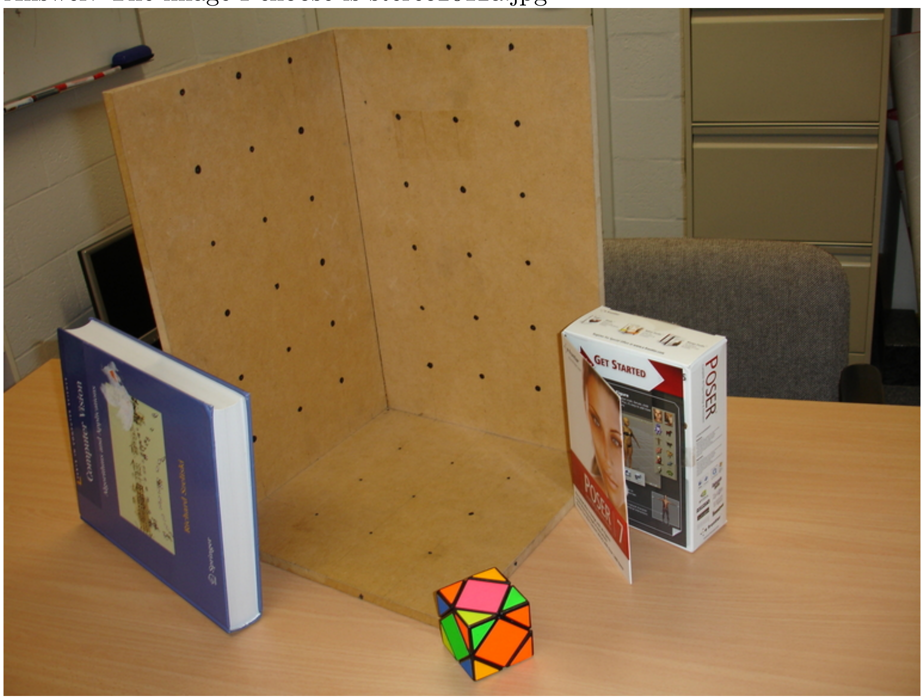
1.1

```python
def calibrate(im, XYZ, uv):
        A = np.zeros((2*(len(XYZ)),12))
        for i in range(A.shape[0]): #for each x_i compute A_i
                if i%2==0:
                        tmp = np.array(XYZ[i//2])
                        A[i,4:8] = (-1*tmp).copy()
                        tmp2 = uv[i//2][1]*tmp
                        A[i,8:] = tmp2.copy()
                else:
                        A[i,:4] = tmp.copy()
                        tmp2=(-1*tmp).copy()
                        tmp2 = uv[i//2][0]*tmp2
                        A[i,8:] = tmp2.copy()
        u,s,v = np.linalg.svd(A) #obtain SVD of A
        C = v[-1]
        C = C.reshape(3,4)
        C = np.linalg.inv(T_norm)@C@S_norm #denormalized
        #print(C)
        return C
```

For calibrate function, there are mainly 4 steps. First, compute A_i for each point. Second, combine all A_i matrices to one A matrix. Third, solve the SVD of A to get C. Fourth, denormalized C and reshape.

1.2

Answer: The image I choose is stereo2012a.jpg

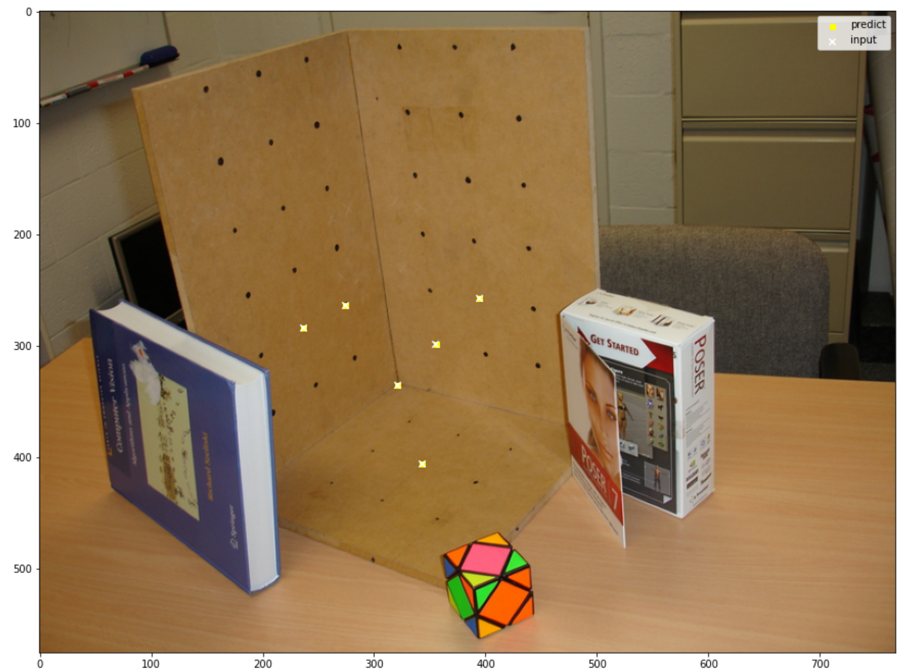


1.3

Answer: matrix P:

[[-1.69926167e+00 , 3.21130575e-01 1.40613179e+00 , -1.03915956e+01]
[-4.35367606e-01 , 1.87301768e+00 -1.08674559e+00 , 1.55109554e+01]
[1.32685851e-03 , 1.21078926e-03 2.41171036e-03 , -3.15885150e-01]]

Matrix P is shown above. For the image below, the white cross label indicated the XYZ coordinate I choose, Yellow square label indicated the coordinate which calculates by matrix P.



1.4

Answer:
Using vgg_KR_from_P.py to decompose the P matrix got matrix K,R and t.
Matrix K:

```
[[ 721.7261638    -4.53488275  168.67624332]
 [  -0.          727.26733597 -102.92671541]
 [  -0.            -0.            1.        ]]
```

matrix R:

```
[[ 0.88693    -0.05960165 -0.45804239]
 [ 0.13662497 -0.91341695  0.38340982]
 [-0.44123554 -0.40263769 -0.80199382]]
```

matrix t:

```
[62.77183476 48.22114397 72.23511016]
```

1.5

Answer:

There are two directions of focal length, for x axis is k_00 in matrix K, for y axis is K_11 in matrix K.
Focal length of the camera is fx = 721.7261638, fy = 727.26733597

For pitch angle to the X-Z plane, θy is the angle we want. The equation is $\theta y = atan2(-R_{31}, \sqrt{r_{32}^2 + r_{33}^2})$.
pitch angle = -26.182739995507493

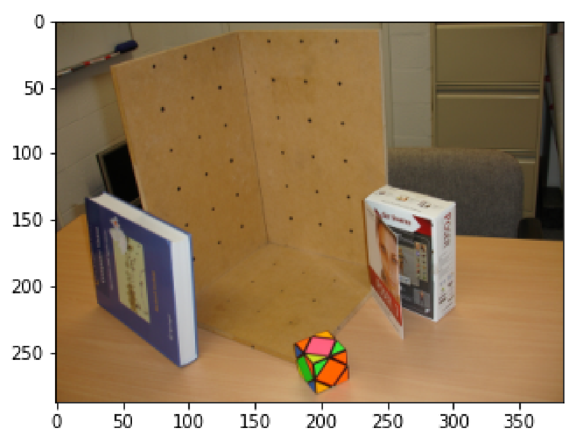
1.6

uv coordinate after resize:

[[160.5, 167.5], [177.5, 149.], [137. , 131.5], [171.5, 203.], [197. , 128.5], [118. , 142.]]

1.6.1 a

Answer: Resized image:



matrix K':

```
[[360.8630819   -2.26744137  84.33812166]
 [ -0.         363.63366798 -51.46335771]
 [ -0.          -0.           1.        ]]
```

matrix R':

```
[[ 0.88693    -0.05960165 -0.45804239]
 [ 0.13662497 -0.91341695  0.38340982]
 [-0.44123554 -0.40263769 -0.80199382]]
```

matrix t':

```
[62.77183476 48.22114397 72.23511016]
```

1.6.2 b

(1)K and K'
From the matrix illustrate, K' is 1/2 of K matrix. Matrix K and K' represent the intrinsic parameters matrix which is the camera parameters. what we do is resize the image to 1/2 of the original image, which means one pixel represents more view than the original one. In this case, K_02, K_12 is half of the origin K_02, K_12, which indicates the cords of principal points. Also, the focal length of x, y-axis, and skew in the y-axis corresponding to K_00, K_11, and K_01 respectively are half of the origin.
(2)R and R'
From the matrix illustrate, R' did not change. R and R' matrix represent the rotation matrix. The new image just resizes the length of the original image, which means the rotation matrix did not change.
(3)t and t'
From the matrix illustrate, t' did not change. t and t' represent the traslation. For resized image and origin image, the translation did not change. So the Translation matrix t and t' will not change.

2

2.1

Answer: For homography estimation function, There are mainly 4 steps. First, compute A_i for each point. Second, combine all A_i to a matrix A. Third, using SVD to solve A got matrix H. Fourth, denormalized H and reshape.

```python

def homography(u2Trans, v2Trans, uBase, vBase):
        A = np.zeros((2*(len(vbase)),9))
        for i in range(A.shape[0]): #compute A_i for each point.
                if i%2==0:
                        tmp = np.array(uBase[i//2])
                        A[i,3:6] = (-1*tmp).copy()
                        A[i,5]=-1
```

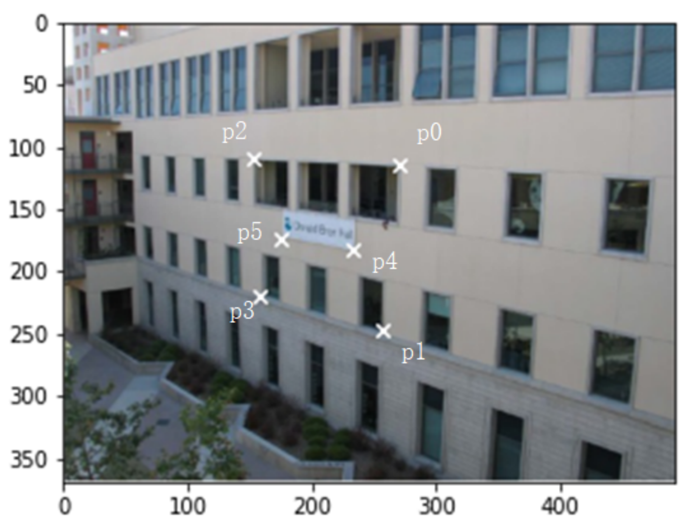
```python

            tmp2 = u2Trans[i//2][1]*tmp
            A[i,6:9] = tmp2.copy()
            A[i,8] = u2Trans[i//2][1]
        else:
            A[i,:3] = tmp.copy()
            A[i,2] = 1

            tmp2=(-1*tmp).copy()
            tmp2 = u2Trans[i//2][0]*tmp2
            A[i,6:9] = tmp2.copy()
            A[i,8] = -1*u2Trans[i//2][0]

    u,s,v = np.linalg.svd(A) #SVD
    C = v[-1]
    C = C.reshape(3,3)
    C = np.linalg.inv(T_norm)@C@T_norm #denormalized
    return C
```

The image below shows the location of six pairs of selected points.



In the below image. The white cross label indicate the six selected points, and yellow square label indicate the predicted point after calculate with matrix H.

2.2

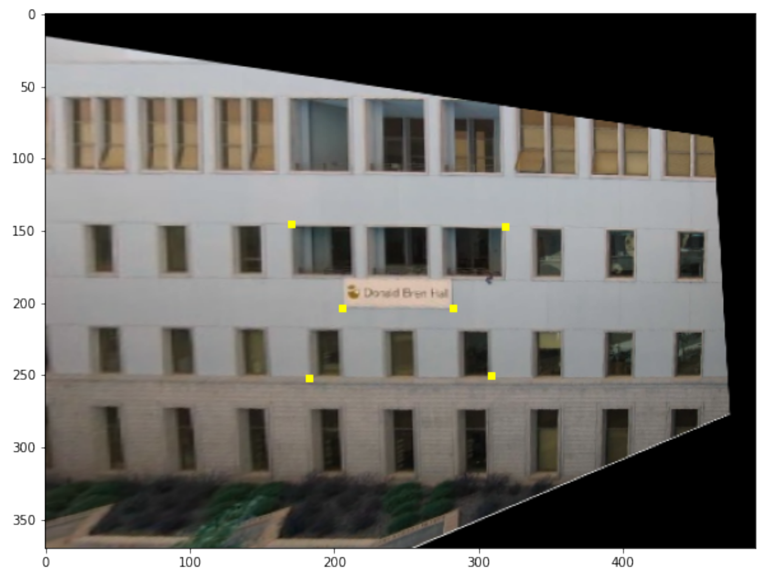
Answer: Using DLT algorithm to calculate matrix H. H shown below

[[6.73269082e-01, 4.92558408e-04, -4.77381102e+01],
[1.14736644e-01, 3.06259861e-01, -3.90225861e+00],
[8.36792499e-04, -3.85192620e-05, 2.00796437e-01]]

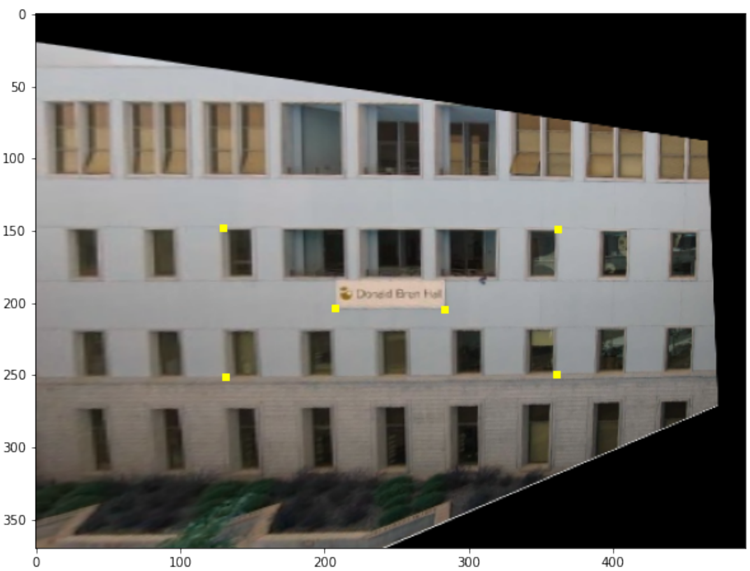
2.3

Answer: Distance for each point in group one is

[0.8552535889510352 , 0.9874512075298797 , 1.5357492316427845 , 1.7922351117891206 , 1.0245671826245484 , 2.275832997005989]



Distance for each point in group two is
[0.2822897315796688 , 1.1773835682240874 , 0.6670013865970991 , 1.1337963387135694 , 0.04076848450723069 , 0.7024475138312357]



As the two images show, the performance of the two images is similar. But the two different matrix show, Those selected points are more sparse have a lower distance than those are dense. In this case, the more sparse selected point has a better performance.