q2-banana

December 12, 2022

[6]:
```python
import numpy as np
import cv2
import matplotlib.pyplot as plt
import os
```

[7]:
```python
# load frogge files
# start from the 12th frame

img_root = './custom-data-dump/banana/seq-1/'
files = os.listdir(img_root)
files.sort()
# files = files[11:]
files = [f for f in files if 'jpg' in f]

images = []
for fl in files :
    im = cv2.imread(img_root + '/' + fl)
    im = cv2.cvtColor(im, cv2.COLOR_BGR2GRAY)
    images.append(im)
images = np.array(images)

image_color = cv2.imread(img_root + '/' + files[0])
image_color = cv2.cvtColor(image_color, cv2.COLOR_BGR2RGB)
```

[8]:
```python
def per_plane_shadow_edge_estimation2(I, offset_row, offset_col) :

    I_max = np.max(I,0)
    I_min = np.min(I,0)
    I_shadow = (I_max + I_min) / 2
    diff_image = np.zeros(I.shape)
    shadow_time = np.zeros(I_shadow.shape)
    for t in range(I.shape[0]) :
        diff_image[t] = I[t] - I_shadow
    line_params = np.zeros((3,I.shape[0]))
    pts_arr = []
    for t in range(diff_image.shape[0]) :
        pts = []
```

```
        for i in range(diff_image.shape[1]):
            cur_pt = []
            cur_neg_count = 0
            for j in range(diff_image.shape[2]-1):

                if diff_image[t][i][j] < 0 : cur_neg_count += 1
                else : cur_neg_count = 0

                if diff_image[t][i][j+1] >= 0 and diff_image[t][i][j] < 0 and␣
 ↪cur_neg_count >= 25:
#                     pts.append([i+offset_row,j+offset_col,1])
                    cur_pt = [i+offset_row,j+offset_col,1]
                    break
            if cur_pt != [] : pts.append(cur_pt)
        if len(pts) == 0 : break
        pts = np.array(pts)
        _,_,vh = np.linalg.svd(pts)
        line_params[:,t] = vh[:,-1]
        pts_arr.append(pts)

    pts_arr = np.array(pts_arr)
    return line_params, pts_arr


def per_pixel_shadow_time_estimate2(I) :

    I_max = np.max(I,0)
    I_min = np.min(I,0)
    I_shadow = (I_max + I_min) / 2
    diff_image = np.zeros(I.shape)
    shadow_time = np.zeros(I_shadow.shape)
    shadow_time_plot = np.zeros(I_shadow.shape)
    for t in range(I.shape[0]) :
        diff_image[t] = I[t] - I_shadow

    bucket_size = diff_image.shape[0] / 32

    for i in range(diff_image.shape[1]):
        for j in range(diff_image.shape[2]):
            diff = -np.inf
            for t in range(diff_image.shape[0]-1):
                if(diff_image[t+1][i][j]-diff_image[t][i][j] > diff):
                    shadow_time[i][j] = t
                    shadow_time_plot[i][j] = t // bucket_size
                    diff = diff_image[t+1][i][j]-diff_image[t][i][j]

    shadow_time[I_max - I_min < 15] = 0
```

```
    shadow_time_plot[I_max - I_min < 15] = 0

    return shadow_time, shadow_time_plot


# horizontal planar bounds
# plt.imshow(images[0,670:,200:820])
# vertical planar bounds
# plt.imshow(images[0,0:300,220:780])
I_hor_start_row, I_hor_end_row = 725, 925 #last is not inclusive
I_hor_start_col, I_hor_end_col = 475, 1200 #last is not inclusive
I_hor_start_frame, I_hor_end_frame = 15, 61

I_ver_start_row, I_ver_end_row = 100, 330 #last is not inclusive
I_ver_start_col, I_ver_end_col = 475, 1200 #last is not inclusive
I_ver_start_frame, I_ver_end_frame = 15, 61


I_horizontal = images[I_hor_start_frame:I_hor_end_frame,
                      I_hor_start_row:I_hor_end_row,
                      I_hor_start_col:I_hor_end_col]

I_vertical = images[I_ver_start_frame:I_ver_end_frame,
                    I_ver_start_row:I_ver_end_row,
                    I_ver_start_col:I_ver_end_col]

line_params_horizontal, pts_hor =␣
 ↪per_plane_shadow_edge_estimation2(I_horizontal/255,␣
 ↪I_hor_start_row,I_hor_start_col)
line_params_vertical, pts_ver = per_plane_shadow_edge_estimation2(I_vertical/
 ↪255, I_ver_start_row, I_ver_start_col)
# pts_ver, pts_hor = pts_ver[7:55], pts_hor[7:55] # for mug-seq1
shadow_time, shadow_time_plot = per_pixel_shadow_time_estimate2(images)
pts_ver, pts_hor = pts_ver[2:-1], pts_hor[2:-1]

# for vertical points selection, 70 and -20
# for horizontal points selection, 10 and -10
```

```
/tmp/ipykernel_101668/194583982.py:33: VisibleDeprecationWarning: Creating an
ndarray from ragged nested sequences (which is a list-or-tuple of lists-or-
tuples-or ndarrays with different lengths or shapes) is deprecated. If you meant
to do this, you must specify 'dtype=object' when creating the ndarray.
  pts_arr = np.array(pts_arr)
```

[9]:
```
%matplotlib notebook
plt.imshow(shadow_time_plot, cmap='jet')
```

```
<IPython.core.display.Javascript object>

<IPython.core.display.HTML object>
```

[9]:
```
<matplotlib.image.AxesImage at 0x7f64adf43bb0>
```

[ ]:
```

```

[10]:
```python
### INTRINSIC AND EXTRINSIC CALIBRATION
from src.cp_hw6 import pixel2ray
# load intrinsic and extrinsic params
intrinsics = np.load('custom-data-dump/calib-dec11/intrinsic_calib.npz')
extrinsics = np.load('custom-data-dump/banana/seq-1/extrinsic_calib.npz')
R_h,t_h = extrinsics['rmat_h'], extrinsics['tvec_h']
R_v,t_v = extrinsics['rmat_v'], extrinsics['tvec_v']
K = intrinsics['mtx']
distortion = intrinsics['dist']
```

[11]:
```python
def ray_plane_intersection(line_pt_plane, r_plane, plane_pt, plane_normal) :

    ndotr = np.dot(r_plane, plane_normal)
    if ndotr == 0 : return None # ray and plane are parallel (won't happen in␣
 ↪our case)

    w = line_pt_plane - plane_pt
    si = -np.dot(w,plane_normal) / ndotr
    Psi = w + si * r_plane + plane_pt

    return Psi

def get_3dpt_from_2dpt(p1,p2, R, t) :

    p = np.array([p1,p2]).astype('float64')
    r = pixel2ray(p, K, distortion) # in camera coordinates
    r = r.squeeze().T # to get 3 * N
    r_plane = R.T @ (r) # 3d rays in plane coordinates
#     r_plane[:,0], r_plane[:,1] = r_plane[:,0] / np.linalg.norm(r_plane[:,0]),␣
 ↪r_plane[:,1] / np.linalg.norm(r_plane[:,1])
    line_pt = np.array([0,0,0]).reshape((3,1))
    line_pt_plane = R.T @ (line_pt - t) # pt on ray line in plane coords
    line_pt_plane = line_pt_plane.squeeze()

    plane_pt = np.array([0,0,0]).reshape((3)) # pt on plane in plane coords
    plane_normal = np.array([0,0,1]).reshape((3)) # plane normal, plane coords

    P1_plane = ray_plane_intersection(line_pt_plane, r_plane[:,0], plane_pt,␣
 ↪plane_normal)
```

```
    P2_plane = ray_plane_intersection(line_pt_plane, r_plane[:,1], plane_pt,␣
↪plane_normal)

    P1_plane = P1_plane.reshape((3,1))
    P2_plane = P2_plane.reshape((3,1))

    P1_cam = R @ P1_plane + t
    P2_cam = R @ P2_plane + t

    return P1_cam, P2_cam
```

[12]:
```
# collecting 3D points (Calibrating shadow lines)

P1_array, P2_array = [], []

for t in range(pts_hor.shape[0]) :
    p1 = pts_hor[t][1][:-1][::-1] # flipping x and y
    p2 = pts_hor[t][-1][:-1][::-1]
    P1, P2 = get_3dpt_from_2dpt(p1, p2, R_h, t_h)
    P1_array.append(P1)
    P2_array.append(P2)

P1_array = np.array(P1_array).squeeze()
P2_array = np.array(P2_array).squeeze()


P3_array, P4_array = [], []

for t in range(pts_ver.shape[0]) :
    p3 = pts_ver[t][1][:-1][::-1]
    p4 = pts_ver[t][-1][:-1][::-1]
    P3, P4 = get_3dpt_from_2dpt(p3, p4, R_v, t_v)
    P3_array.append(P3)
    P4_array.append(P4)

P3_array = np.array(P3_array).squeeze()
P4_array = np.array(P4_array).squeeze()

%matplotlib notebook

fig = plt.figure()
ax = fig.add_subplot(projection='3d')
ax.scatter(P1_array[:,0],P1_array[:,1],P1_array[:,2], c='r')
ax.scatter(P2_array[:,0],P2_array[:,1],P2_array[:,2], c='r')
ax.scatter(P3_array[:,0],P3_array[:,1],P3_array[:,2], c='g')
ax.scatter(P4_array[:,0],P4_array[:,1],P4_array[:,2], c='b')
```

```
<IPython.core.display.Javascript object>
```

```
<IPython.core.display.HTML object>
```

[12]:
```
<mpl_toolkits.mplot3d.art3d.Path3DCollection at 0x7f64add50ca0>
```

[13]:
```python
def get_shadow_plane(P1, P2, P3, P4) :

    n = np.cross((P2-P1), (P4-P3))
    n_norm = n / np.linalg.norm(n)

    return P1, n_norm

def get_3d_point_on_shadow_plane(p, S) :

    p = np.array([p,p]).astype('float64')
    r = pixel2ray(p, K, distortion) # in camera coordinates
    r = r.squeeze().T # to get 3 * N

    line_pt = np.array([0,0,0])
    plane_normal = S['n_norm']
    plane_point = S['P1']

    P = ray_plane_intersection(line_pt, r[:,0], plane_point, plane_normal)

    return P
```

[14]:
```python
# Calibrating Shadow planes
n_array = []
S_array = []
for t in range(len(P1_array)) :
    _, n_norm = ␣
↪get_shadow_plane(P1_array[t],P2_array[t],P3_array[t],P4_array[t])
    n_array.append(n_norm)
    S_array.append({'P1' : P1_array[t], 'n_norm' : n_norm})
n_array = np.array(n_array)
```

[38]:
```python
### RECONSTRUCTION

rectangle_bounds_col = [520,1190] #790]#815]
rectangle_bounds_row = [350,666]#630]
P_array = []
p_color_array = []
for row in range(rectangle_bounds_row[0],rectangle_bounds_row[1],4) :
    for col in range(rectangle_bounds_col[0],rectangle_bounds_col[1],4) :

        st = shadow_time[row, col]
        st_offset_adjusted = int(st - I_ver_start_frame)
```

```
        if st_offset_adjusted < 0 : st_offset_adjusted = 0
        if st_offset_adjusted > len(S_array)-1 : st_offset_adjusted =␣
↪len(S_array)-1
        S = S_array[st_offset_adjusted]
        p = np.array([col, row]) # row and col have been swapped intentionally
        P = get_3d_point_on_shadow_plane(p, S)
        P_array.append(P)

        p_color_array.append(image_color[row, col])

P_array = np.array(P_array)
p_color_array = np.array(p_color_array)
```

[43]:
```
# filtering points
# 1) on magnitude

# for just frog
# P_array_filtered = P_array[np.linalg.norm(P_array, axis=1) < 2000 ]
# p_color_array_filtered = p_color_array[np.linalg.norm(P_array, axis=1) < 2000␣
↪]

# # for frog with background
P_array_filtered = P_array[P_array[:,2]<2500]
p_color_array_filtered = p_color_array[P_array[:,2]<2500]

p_color_array_filtered = p_color_array_filtered[P_array_filtered[:,2]>-1000]
P_array_filtered = P_array_filtered[P_array_filtered[:,2]>-1000]

# p_color_array_filtered = p_color_array_filtered[P_array_filtered[:,0]>-75]
# P_array_filtered = P_array_filtered[P_array_filtered[:,0]>-75]
```

[44]:
```
%matplotlib notebook

fig = plt.figure()
ax = fig.add_subplot(projection='3d')
ax.scatter(P_array_filtered[:,0],P_array_filtered[:,1],P_array_filtered[:
↪,2],c=p_color_array_filtered/255)
```

<IPython.core.display.Javascript object>

<IPython.core.display.HTML object>

[44]: <mpl_toolkits.mplot3d.art3d.Path3DCollection at 0x7f64a894fee0>

[ ]:

[ ]:

[ ]:

```

```

[37]:

```
%matplotlib notebook
frame_no = 40
plt.figure()
plt.imshow(images[15+frame_no])
# plt.scatter(pts_hor[frame_no][:,1],pts_hor[frame_no][:,0])
plt.scatter(pts_ver[frame_no][:,1],pts_ver[frame_no][:,0])
# print(pts_ver[frame_no][70])
```

```
<IPython.core.display.Javascript object>
```

```
<IPython.core.display.HTML object>
```

[37]:

```
<matplotlib.collections.PathCollection at 0x7f64a81190c0>
```

[ ]:

```
P_array_filtered[P_array_filtered[:,2]>1500].shape
```

[ ]:

```
P_array[np.linalg.norm(P_array, axis=1) < 4000 ].shape
```

[ ]:

```
p_color_array_filtered / 255
```

[ ]:

```
%matplotlib notebook
plt.imshow(images[60])
```

[ ]:

```
I = images.copy()
I_max = np.max(I,0)
I_min = np.min(I,0)
I_shadow = (I_max + I_min) / 2
diff_image = np.zeros(I.shape)
shadow_time = np.zeros(I_shadow.shape)
for t in range(I.shape[0]) :
    diff_image[t] = I[t] - I_shadow
```

[ ]:

```
diff_image[20][100][475:550]
```

[115]:

```
pts_hor.shape
```

[115]:

```
(44,)
```

[ ]:

```

```