

q2-stand

December 12, 2022

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

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

img_root = './custom-data-dump/stand/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)
```

```
[5]: 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 = []
```

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    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 = 850, 1000 #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 = 25, 71

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 = 25, 71

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)

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

```

/tmp/ipykernel_101699/1480845928.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)
```

```

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

```

<IPython.core.display.Javascript object>

<IPython.core.display.HTML object>

[6]: <matplotlib.image.AxesImage at 0x7fd4f54b18d0>

[]:

[7]: *### INTRINSIC AND EXTRINSIC CALIBRATION*

```
from src.cp_hw6 import pixel2ray
# load intrinsic and extrinsic params
intrinsics = np.load('custom-data-dump/calib-decl1/intrinsic_calib.npz')
extrinsics = np.load('custom-data-dump/stand/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']
```

[8]: **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

```

```

[9]: # 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>

[9]: <mpl_toolkits.mplot3d.art3d.Path3DCollection at 0x7fd4f55e5c90>

```
[10]: 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
```

```
[11]: # 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)
```

```
[12]: ### RECONSTRUCTION

rectangle_bounds_col = [640,1100] #790]#815]
rectangle_bounds_row = [430,800]#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)

```

```

[13]: # 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]<3500]
      p_color_array_filtered = p_color_array[P_array[:,2]<3500]

      p_color_array_filtered = p_color_array_filtered[P_array_filtered[:,2]>500]
      P_array_filtered = P_array_filtered[P_array_filtered[:,2]>500]

      print(P_array_filtered.shape)
      P_array_filtered = P_array_filtered[np.sum(p_color_array_filtered,1) < 300]
      p_color_array_filtered = p_color_array_filtered[np.
↪sum(p_color_array_filtered,1) < 300]
      print(P_array_filtered.shape)
      # P_array_filtered = P_array_filtered[p_color_array_filtered[:,1] < 110]
      # p_color_array_filtered = p_color_array_filtered[p_color_array_filtered[:,1] <
↪110]

      # print(P_array_filtered.shape)
      # P_array_filtered = P_array_filtered[p_color_array_filtered[:,2] < 110]
      # p_color_array_filtered = p_color_array_filtered[p_color_array_filtered[:,2] <
↪110]

      # print(P_array_filtered.shape)

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

```

(6934, 3)

(2712, 3)

```
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.HTML object>
```

[]:

[]:

```
image_color[600,675:950]
```

[illegible]

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[ 94,  62,  49],
[ 97,  65,  52]], dtype=uint8)

```

```

[38]: %matplotlib notebook
frame_no = 45
plt.figure()
plt.imshow(images[25+frame_no])
plt.scatter(pts_hor[frame_no][1,1],pts_hor[frame_no][1,0])
# 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>

[38]: <matplotlib.collections.PathCollection at 0x7fd1d23982b0>

```
[ ]: 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]
```

```
[32]: pts_hor[frame_no].shape
```

[32]: (7, 3)

```
[57]: %matplotlib
plt.imshow(image_color)
```

Using matplotlib backend: nbAgg

<IPython.core.display.Javascript object>

<IPython.core.display.HTML object>

[57]: <matplotlib.image.AxesImage at 0x7fd1d1cccbb0>

```
[85]: p_color_array_filtered.shape
```

[85]: (6934, 3)

```
[ ]:
```