05_BlockMatching_HarrisCorners_final

November 27, 2019

1 Assignment 5: Block Matching and Harris Corner Detection

1.1 Ex. 5.1 Dense Optical Flow by Block Matching

- implement the block matching method as shown in the lecture
- take two frames from the datasets "lane_detection" or "copter_flight" with variable distances in time (1, 2, x) and compute the vector flow field
- display a subset of flow vectors on the gray-value version of the first image, by drawing a respective line. adjust the grid density such that not too many vectors overlap (**RESULT**)

[3]:
```
%matplotlib inline
import matplotlib.pyplot as plt
from skimage import io, data, feature, color
import numpy as np

# Chose other images if you like
lane1 = io.imread('images/lane_detection/f00000.png')
lane2 = io.imread('images/lane_detection/f00001.png')

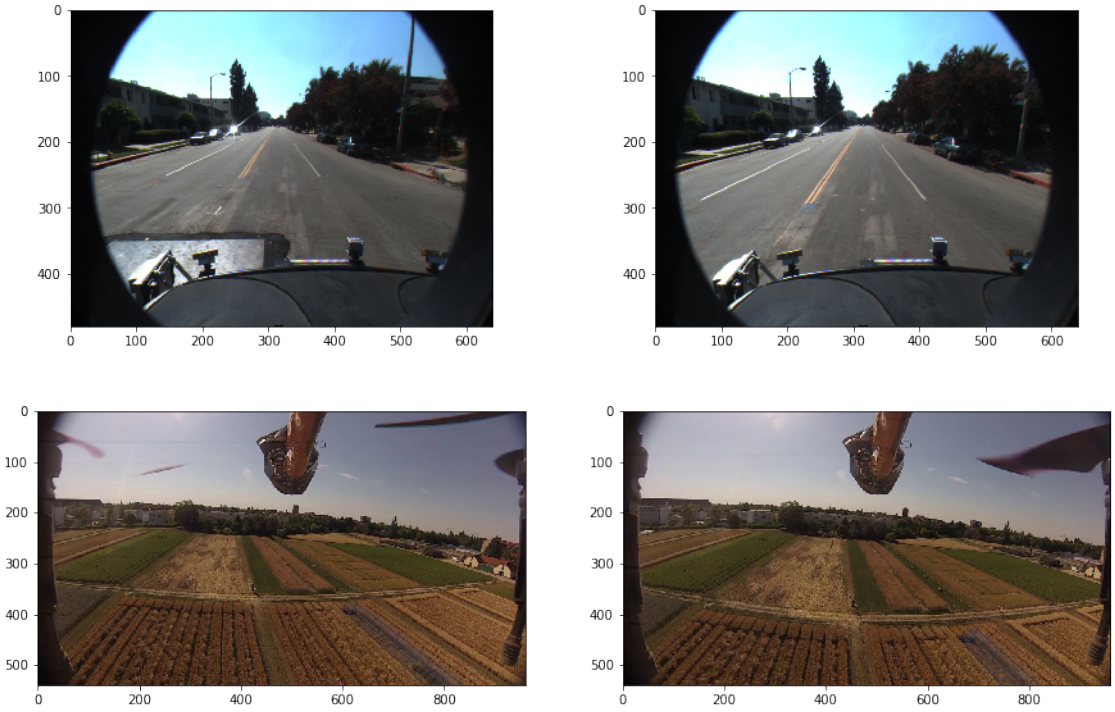
# Footage from our Neurocopter project:
# http://berlinbiorobotics.blog/projects/neurocopter/
copter1 = io.imread('images/copter_flight/frame050.jpg')
copter2 = io.imread('images/copter_flight/frame052.jpg')

fig = plt.figure(figsize=(15, 10))
ax11 = plt.subplot(2, 2, 1)
ax12 = plt.subplot(2, 2, 2)
ax21 = plt.subplot(2, 2, 3)
ax22 = plt.subplot(2, 2, 4)

ax11.imshow(lane1)
ax12.imshow(lane2)

ax21.imshow(copter1)
ax22.imshow(copter2)
```

[3]:
```
<matplotlib.image.AxesImage at 0x1079bdc50>
```



[108]:
```
from skimage import io, data, feature, color
import numpy as np


def get_window_coords(x, y, window_size, shape=None, clip=None, as_tuple=False):
    """
    :param window_size: (height, width) values should be odd

    Returned values are exclusive so ready for slicing.
    """

    delta_y, delta_x = window_size // 2
    if clip:
        clip_y, clip_x = clip
    else:
        assert shape, "'shape' argument required, when 'clip' is not given"
        height, width = shape
        clip_y = (0, height)
        clip_x = (0, width)
    y_min, y_max = np.clip(np.array([y - delta_y, y + delta_y + 1]), *clip_y)
    x_min, x_max = np.clip(np.array([x - delta_x, x + delta_x + 1]), *clip_x)
    if as_tuple:
        # No 'step' value here...
        return ((y_min, y_max), (x_min, x_max))
```

```
    return np.s_[y_min:y_max, x_min:x_max]


def get_window(image, x, y, window_size, shape):
    return image[get_window_coords(x, y, window_size, shape)]


def calc_ssd(image, x, y, dx, dy, block, shape):
    ty, tx = y + dy, x + dx
    shifted_block = get_window(image, tx, ty, BLOCK_SIZE, shape)
    return np.sum(np.square(block - shifted_block))


def calc_flow(image, x, y, block, shape):
    flow_vector = None
    min_ssd = None
    ref = np.array([x, y])

    height, width = shape
    pad_y, pad_x = block_size // 2
    clip = ((pad_y, height - pad_y), (pad_x, width - pad_x))
    (y_min, y_max), (x_min, x_max) = get_window_coords(
        x, y,
        SEARCH_WINDOW_SIZE,
        clip=clip,
        as_tuple=True,
    )
    for yi in range(y_min, y_max):
        for xi in range(x_min, x_max):
            dx, dy = np.array([xi, yi]) - ref
            ssd = calc_ssd(image, x, y, dx, dy, block, shape)
            if min_ssd is None or ssd < min_ssd:
                min_ssd = ssd
                flow_vector = np.array([dx, dy])
    return flow_vector


store = {}
BLOCK_SIZE = np.array([11, 11])
SEARCH_WINDOW_SIZE = np.array([71, 71])
sequence = [color.rgb2gray(image) for image in [lane1, lane2]]
shape = sequence[0].shape
print(shape)
for t, image in enumerate(sequence[1:], start=1):
    for x, y in [
        [424, 198],
        [230, 97],
```

```
        [313, 259],
        # Street sign...not working so well.
        # [496, 153],
    ]:
        print(f'at x={x}, y={y}. finding flow vector...')
        block = get_window(sequence[t - 1], x, y, BLOCK_SIZE, shape)
        search_window = get_window(image, x, y, SEARCH_WINDOW_SIZE, shape)
        flow_vector = calc_flow(image, x, y, block, shape)
        store[(x, y)] = flow_vector

print(store)
None
```

```
(480, 640)
at x=424, y=198. finding flow vector…
at x=230, y=97. finding flow vector…
at x=313, y=259. finding flow vector…
{(424, 198): array([27,  0]), (230, 97): array([-7, -8]), (313, 259): array([ 2,
26])}
```

[109]:
```
from skimage.draw import line, rectangle_perimeter as rect


N = len(store)
fig = plt.figure(figsize=(18, 10*N), dpi=72)
fig.tight_layout()
grid = fig.add_gridspec(N + 2, 2)

res_img = np.copy(lane2)
for i, ((x, y), (dx, dy)) in enumerate(store.items()):
    rr, cc = line(y, x, y + dy, x + dx)
    res_img[rr, cc] = np.array([255, 0, 0])
    (y_min, y_max), (x_min, x_max) = get_window_coords(x + dx, y + dy,␣
 ↪BLOCK_SIZE, shape, as_tuple=True)
    rr, cc = rect((y_min, x_min), (y_max, x_max), shape=shape)
    res_img[rr, cc] = np.array([0, 255, 0])

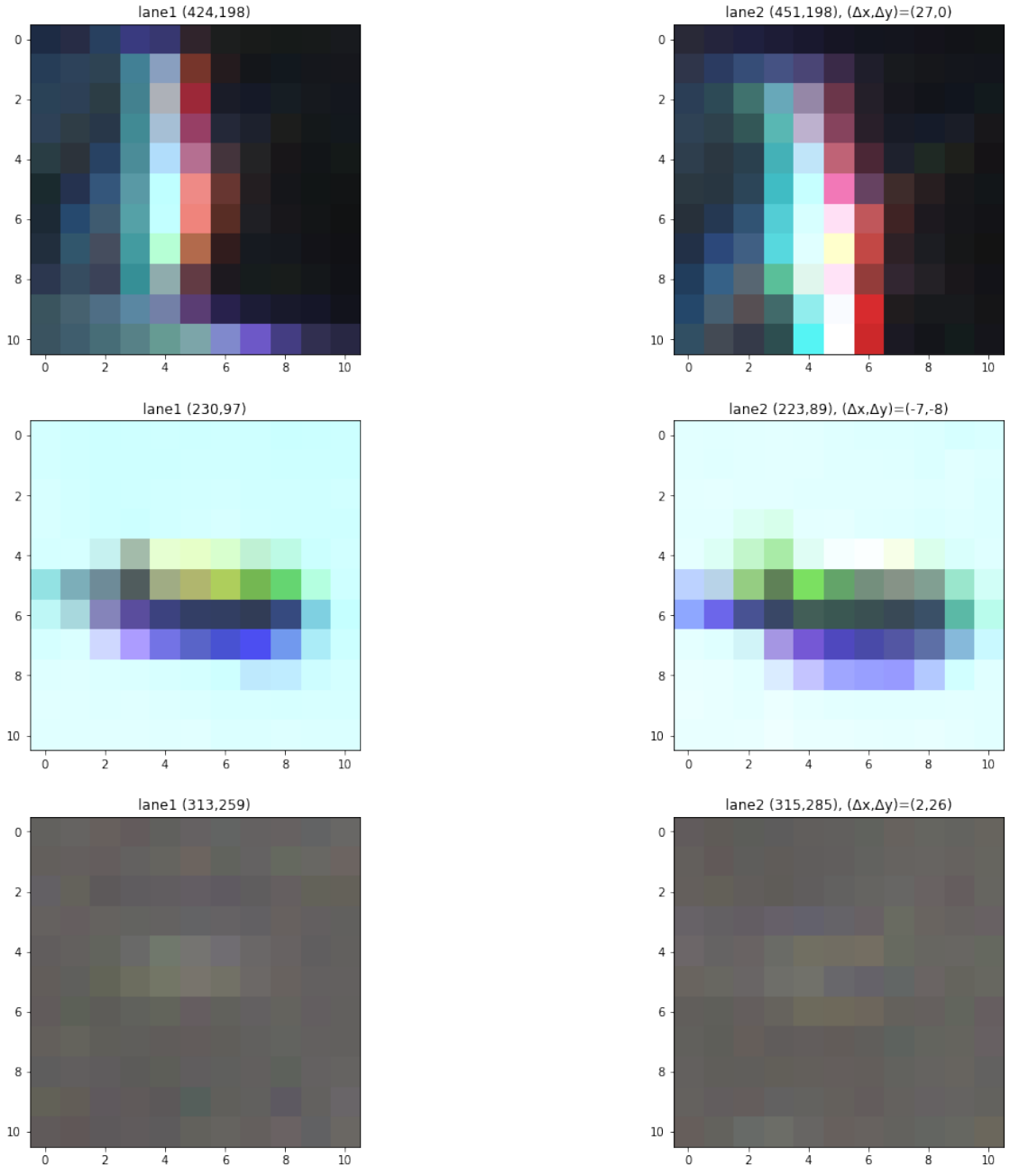
    ax1 = fig.add_subplot(grid[i, 0])
    ax2 = fig.add_subplot(grid[i, 1])

    ax1.imshow(get_window(lane1, x, y, block_size, shape))
    ax1.set_title(f'lane1 ({x},{y})')
    ax2.imshow(get_window(lane2, x + dx, y + dy, block_size, shape))
    ax2.set_title(f'lane2 ({x + dx},{y + dy}), (Δx,Δy)=({dx},{dy})')


fig = plt.figure(figsize=(18, 20), dpi=72)
```

```
ax1 = plt.subplot(2, 1, 1)
ax2 = plt.subplot(2, 1, 2)
ax1.set_title(f'lane1')
ax1.imshow(lane1)
ax2.set_title(f'lane2')
ax2.imshow(res_img)

plt.show()
None
```




lane1
0
100
200
300
400
0
100
200
300
400
500
600


lane2
0
100
200
300
400
0
100
200
300
400
500
600

[112]:
```
from skimage.draw import line


store_big = {}
STEP_SIZE = BLOCK_SIZE[0] * 2
for t, image in enumerate(sequence[1:], start=1):
    pad_y, pad_x = block_size // 2
    for x in range(pad_x, shape[1] - pad_x, STEP_SIZE):
        for y in range(pad_y, shape[0] - pad_y, STEP_SIZE):
            print(f'at x={x}, y={y}. finding flow vector...')
            block = get_window(sequence[t - 1], x, y, BLOCK_SIZE, shape)
            search_window = get_window(image, x, y, SEARCH_WINDOW_SIZE, shape)
            flow_vector = calc_flow(image, x, y, block, shape)
            store_big[(x, y)] = flow_vector

print(store_big)


fig = plt.figure(figsize=(18, 10), dpi=72)
res_img = np.copy(lane2)
for i, ((x, y), (dx, dy)) in enumerate(store_big.items()):
    rr, cc = line(y, x, y + dy, x + dx)
    res_img[rr, cc] = np.array([255, 0, 0])

io.imshow(res_img)
```

```
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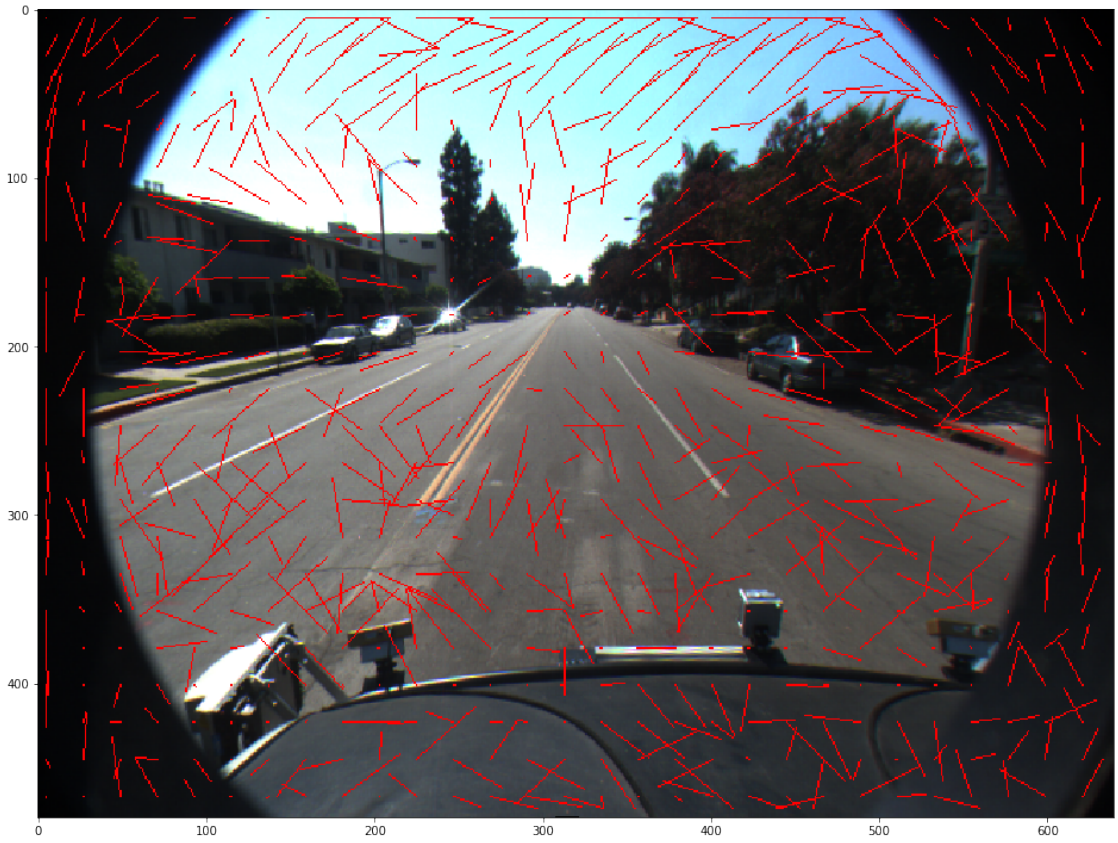
[112]: <matplotlib.image.AxesImage at 0x1318af710>



1.2 Ex. 5.2 Harris Corner Detection

- implement the Harris Corner Detector as discussed in the lecture
- compute corners in the first image and track them with Lucas-Kanade (use e.g. the function "calcOpticalFlowPyrLK" in OpenCV)
- mark the positions of your Harris corners and draw the flow vectors found by Lucas-Kanade on the gray-value versions of the first image (**RESULT**)

[4]:
```
from skimage import color, filters

im = color.rgb2gray(copter1)
im_width, im_height = im.shape
H = np.empty([im_width, im_height, 4])
R = np.empty([im_width, im_height])
k = 0.04

print(im_width, im_height)

# 1) Compute derivations of I
I_x = filters.sobel_h(im)
I_y = filters.sobel_v(im)
```

```
# 2) Compute products of derivatives at every pixel
I_x2 = I_x*I_x
I_y2 = I_y*I_y
I_xy = I_x*I_y

# 3) Compute sums of products at every pixel
S_x2 = filters.sobel(I_x2)
S_y2 = filters.sobel(I_y2)
S_xy = filters.sobel(I_xy)

# 4) Define matrix at each pixel
for x in range(im_width):
    for y in range(im_height):
        H[x][y][0] = S_x2[x][y]
        H[x][y][1] = S_xy[x][y]
        H[x][y][2] = S_xy[x][y]
        H[x][y][3] = S_y2[x][y]

# 5) Compute detector response: R = det H - k* trace H **2            det=ad-bc
 ↪   trace=a+d
for x in range(im_width):
    for y in range(im_height):
        det = (H[x][y][0]*H[x][y][3]) - (H[x][y][1]*H[x][y][2]) # second term
 ↪always zero therefore obsolet, right?
        trace = H[x][y][0]+H[x][y][3]
        R[x][y] = det - k*(np.power(trace,2))
```

```
540 960
```

[5]:
```
# 6) Threshold the value of R. Compute nonmax suppression
R[R <= 0.005] = 0
rmax = R.max()
rmin = R.min()
print(rmax, rmin)
print(np.count_nonzero(R))

kernel_size = 3
result = np.zeros([im_width, im_height])

LC_vec = []

for x in range(im_width-(kernel_size-1)):
    for y in range(im_height-(kernel_size-1)):
        R_window = R[x:x+kernel_size,y:y+kernel_size]
        score = np.sum(R_window)
        result[x+1][y+1] = score
```

```
#second Treshold to reduce LC vector length
#result[result <= 0.04] = 0
#print(np.count_nonzero(result))

for x in range(im_width):
    for y in range(im_height):
        if(result[x][y] != 0.0):
            LC_vec.append((x,y))

# print(len(LC_vec))
# print(LC_vec)


fig = plt.figure(figsize=(20, 15))
plt.imshow(result, cmap='gray')
```

```
0.06350638982074053 0.0
180
```

[5]: <matplotlib.image.AxesImage at 0x12f103d50>

[6]:
```
# Get most valuable Harris Corner
corner = np.argmax(result)
corner_x = corner / im_height
corner_y = corner % im_height
```

```
HC = (corner_y, corner_x)
print(HC)
```

```
(491, 90.51145833333334)
```

[8]:
```
import cv2 as cv


copter1_gray = cv.imread('images/copter_flight/frame050.jpg', cv.
 ↪IMREAD_GRAYSCALE)
copter2_gray = cv.imread('images/copter_flight/frame052.jpg', cv.
 ↪IMREAD_GRAYSCALE)
print(type(copter2_gray))

lk_params = dict( winSize  = (15, 15),
                  maxLevel = 2,
                  criteria = (cv.TERM_CRITERIA_EPS | cv.TERM_CRITERIA_COUNT,␣
 ↪10, 0.03))
prevPts = np.array(LC_vec, dtype=np.float32)
nextPts, status, err = cv.calcOpticalFlowPyrLK(
    copter1_gray, copter2_gray,
    prevPts,
    None,
#     [None for i in range(len(LC_vec))],
    **lk_params
)
print(nextPts.shape, '--', status.shape, err.shape)
```

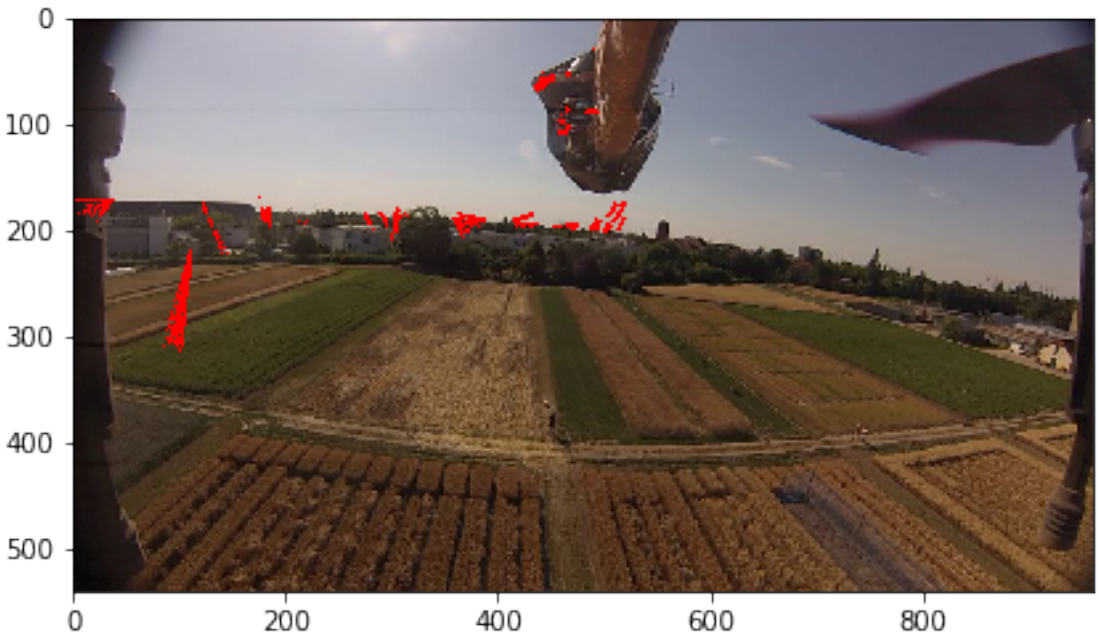
```
<class 'numpy.ndarray'>
(1033, 2) -- (1033, 1) (1033, 1)
```

[9]:
```
from skimage.draw import line

res_img = np.copy(copter2)
for p, n, stat in zip(prevPts, nextPts, status):
    if stat == 1:
        y1, x1 = p.astype(np.uint)
        y2, x2 = n.astype(np.uint)
        rr, cc = line(y1, x1, y2, x2)
        res_img[rr, cc] = [255, 0, 0]

io.imshow(res_img)
```

[9]:
```
<matplotlib.image.AxesImage at 0x12d98c090>
```


0
100
200
300
400
500
0
200
400
600
800