190648C

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ASSIGNMENT 03

https://github.com/SasininduSV/EN2550-Assignments-03.git

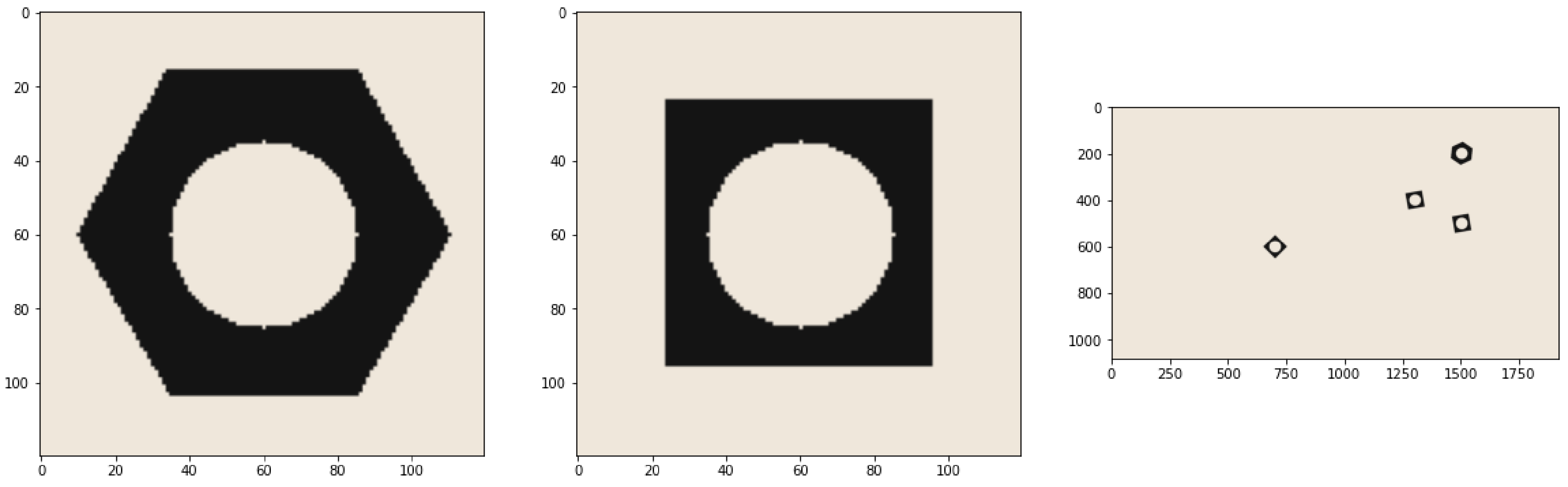
EN2550: Assignment 03 on Object Counting on a Conveyor Belt

Connected Component Analysis

In this part, we will generate an indexed image representing connected components in `conveyor_f101.png` image. Notice that, as there are three square nuts and one hexagonal nut in the image, there will be five connected components (backgound will be assigned the label 0).

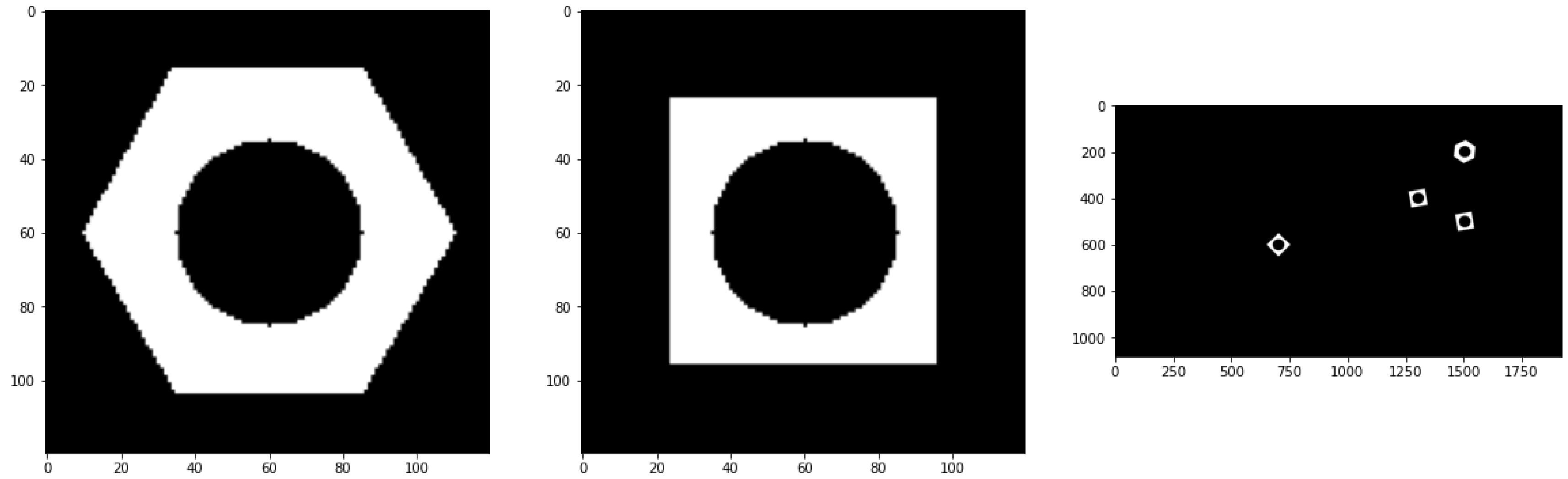
1. Open the `hexnut_template.png`, `squarenut_template.png` and `conveyor_f100.png` and display. This is done for you.

In [ ]:
```
import cv2 as cv
import numpy as np
import matplotlib.pyplot as plt

hexnut_template = cv.imread(r'Assignment-03 Materials\hexnut_template.png', cv.IMREAD_COLOR)
squarenut_template =  cv.imread(r'Assignment-03 Materials\squarenut_template.png', cv.IMREAD_COLOR)
conveyor_f100 =  cv.imread(r'Assignment-03 Materials\conveyor_f100.png', cv.IMREAD_COLOR)

fig, ax = plt. subplots(1,3,figsize=(20,6))
ax[0].imshow(cv.cvtColor(hexnut_template, cv.COLOR_RGB2BGR))
ax[1].imshow(cv.cvtColor(squarenut_template, cv.COLOR_RGB2BGR))
ax[2].imshow(cv.cvtColor(conveyor_f100, cv.COLOR_RGB2BGR))
plt.show()
```



1. Convert the images to grayscale and apply Otsu's thresholding to obtain the binarized image. Do this for both the templates and belt images. See https://docs.opencv.org/master/d7/d4d/tutorial_py_thresholding.html for a guide. State the threshold value (automatically) selected in the operation. Display the output images.

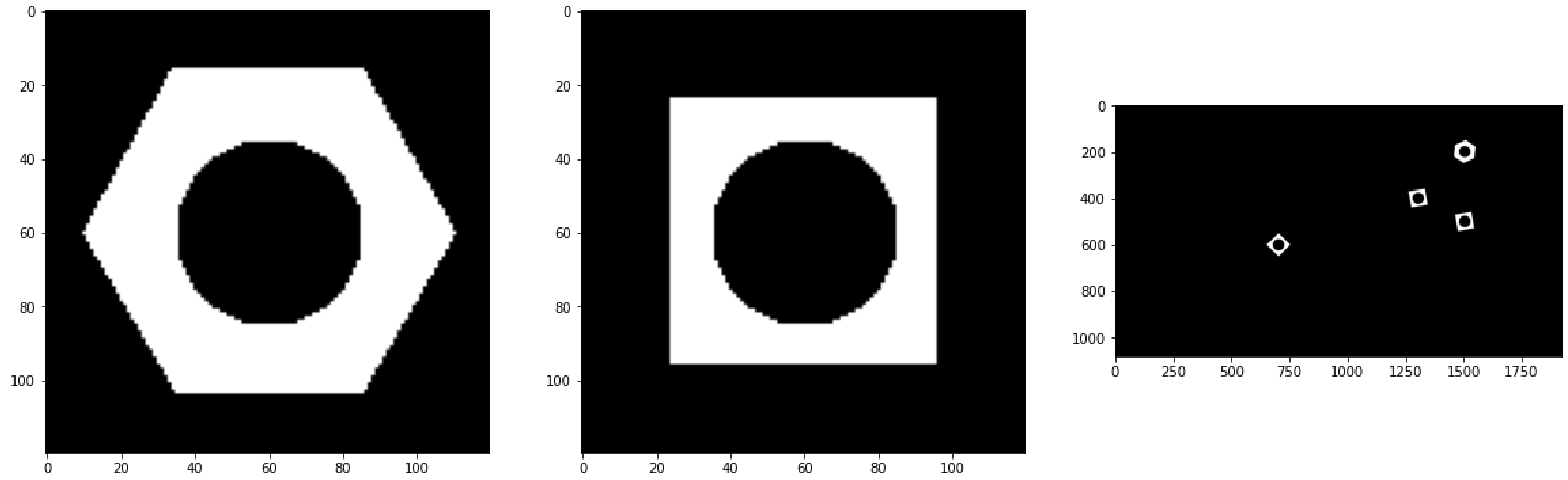
In [ ]:
```
hexnut_template = cv.cvtColor(hexnut_template,cv.COLOR_BGR2GRAY)
squarenut_template = cv.cvtColor(squarenut_template, cv.COLOR_BGR2GRAY)
conveyor_f100 = cv.cvtColor(conveyor_f100, cv.COLOR_BGR2GRAY)

# applying Otsu's thresholding
ret1,hexnut_template = cv.threshold(hexnut_template,0,255,cv.THRESH_OTSU)
ret2,squarenut_template = cv.threshold(squarenut_template,0,255,cv.THRESH_OTSU)
ret3,conveyor_f100 = cv.threshold(conveyor_f100,0,255,cv.THRESH_OTSU)

hexnut_template = np.invert(hexnut_template)
squarenut_template = np.invert(squarenut_template)
conveyor_f100 = np.invert(conveyor_f100)

fig, ax = plt. subplots(1,3,figsize=(20,6))
ax[0].imshow(hexnut_template, cmap='gray', vmin=0, vmax=255)
ax[1].imshow(squarenut_template, cmap='gray', vmin=0, vmax=255)
ax[2].imshow(conveyor_f100, cmap='gray', vmin=0, vmax=255)
plt.show()

print("Treshold value (automatically) =", ret1)
```



```
Treshold value (automatically) = 20.0
```

1. Carry out morphological closing to remove small holes inside the foreground. Use a 3×3 kernel. See https://docs.opencv.org/master/d9/d61/tutorial_py_morphological_ops.html for a guide.

In [ ]:
```
kernel = np.ones((3,3), np.uint8)
hexnut_template = cv.morphologyEx(hexnut_template, cv.MORPH_CLOSE, kernel)
squarenut_template = cv.morphologyEx(squarenut_template, cv.MORPH_CLOSE, kernel)
conveyor_f100 = cv.morphologyEx(conveyor_f100, cv.MORPH_CLOSE, kernel)

fig, ax = plt. subplots(1,3,figsize=(20,6))
ax[0].imshow(hexnut_template, cmap='gray', vmin=0, vmax=255)
ax[1].imshow(squarenut_template, cmap='gray', vmin=0, vmax=255)
ax[2].imshow(conveyor_f100, cmap='gray', vmin=0, vmax=255)
plt.show()
```

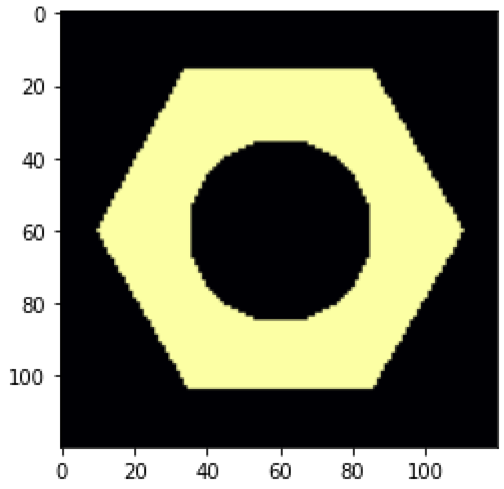


1. Connected components analysis: apply the `connectedComponentsWithStats` function (see https://docs.opencv.org/4.5.5/d3/dc0/group__imgproc__shape.html#ga107a78bf7cd25dec05fb4dfc5c9e765f) and display the outputs as colormapped images. Answer the following questions

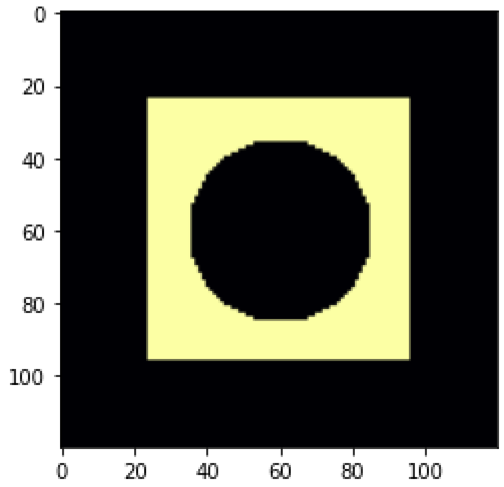
- How many connected components are detected in each image?
- What are the statistics? Interpret these statistics.
- What are the centroids?

For the hexnut template, you should get the object area in pixel as approximately `4728`.

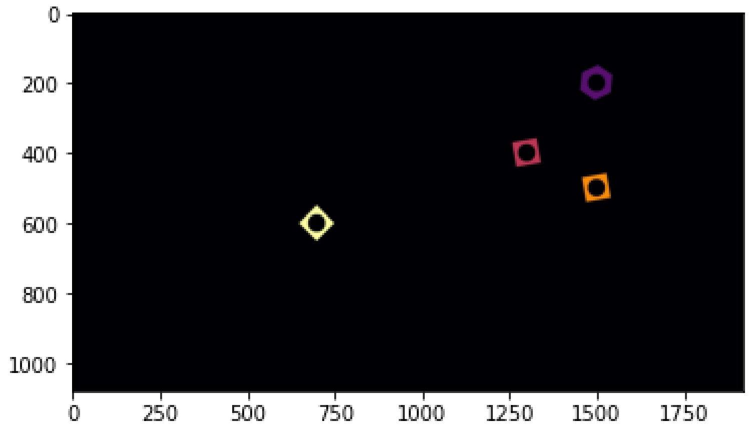
In [ ]:
```
images = ['hexnut_template','squarenut_template','conveyor_f100']

for i in range(3):
    nlabels, labels, stats, centroids = cv.connectedComponentsWithStats(eval(images[i]))
    labels = np.uint8(labels)
    labels = cv.normalize(labels, None, 0, 255, cv.NORM_MINMAX)
    labels = cv.applyColorMap(labels, cv.COLORMAP_INFERNO)

    fig, ax = plt.subplots()
    ax.imshow(cv.cvtColor(labels, cv.COLOR_BGR2RGB))
    plt.show()
    print("No of connected components - {} (without the background)".format(nlabels-1))
    for k in range(1,nlabels):
        print("\n---Component {}".format(k))
        print("* The starting x coordinate of the component - {}      * The starting y coordinate of the component - {}"
        print("* The width of the component - {}      * The height of the component - {}".format(stats[k,cv.CC_STAT_WIDT
        print("* The area of the component - {}".format(stats[k,cv.CC_STAT_AREA]))
        print("* The centroid (x, y) coordinates of the component - {}".format(centroids[k]))
```



```
No of connected components - 1 (without the background)

---Component 1
* The starting x coordinate of the component - 10     * The starting y coordinate of the component - 16
* The width of the component - 101     * The height of the component - 88
* The area of the component - 4728
* The centroid (x, y) coordinates of the component - [59.83375635 59.22356176]
```



```
No of connected components - 1 (without the background)

---Component 1
* The starting x coordinate of the component - 24     * The starting y coordinate of the component - 24
* The width of the component - 72     * The height of the component - 72
* The area of the component - 3227
* The centroid (x, y) coordinates of the component - [59.19677719 59.19677719]
```



```
No of connected components - 4 (without the background)

---Component 1
* The starting x coordinate of the component - 1454     * The starting y coordinate of the component - 150
* The width of the component - 92     * The height of the component - 100
* The area of the component - 4636
* The centroid (x, y) coordinates of the component - [1499.24201898  199.28515962]

---Component 2
* The starting x coordinate of the component - 1259     * The starting y coordinate of the component - 359
* The width of the component - 82     * The height of the component - 82
* The area of the component - 3087
* The centroid (x, y) coordinates of the component - [1299.18302559  399.18302559]

---Component 3
* The starting x coordinate of the component - 1459     * The starting y coordinate of the component - 459
* The width of the component - 82     * The height of the component - 82
* The area of the component - 3087
* The centroid (x, y) coordinates of the component - [1499.18302559  499.18302559]

---Component 4
* The starting x coordinate of the component - 650     * The starting y coordinate of the component - 550
* The width of the component - 101     * The height of the component - 101
* The area of the component - 3144
* The centroid (x, y) coordinates of the component - [700. 600.]
```

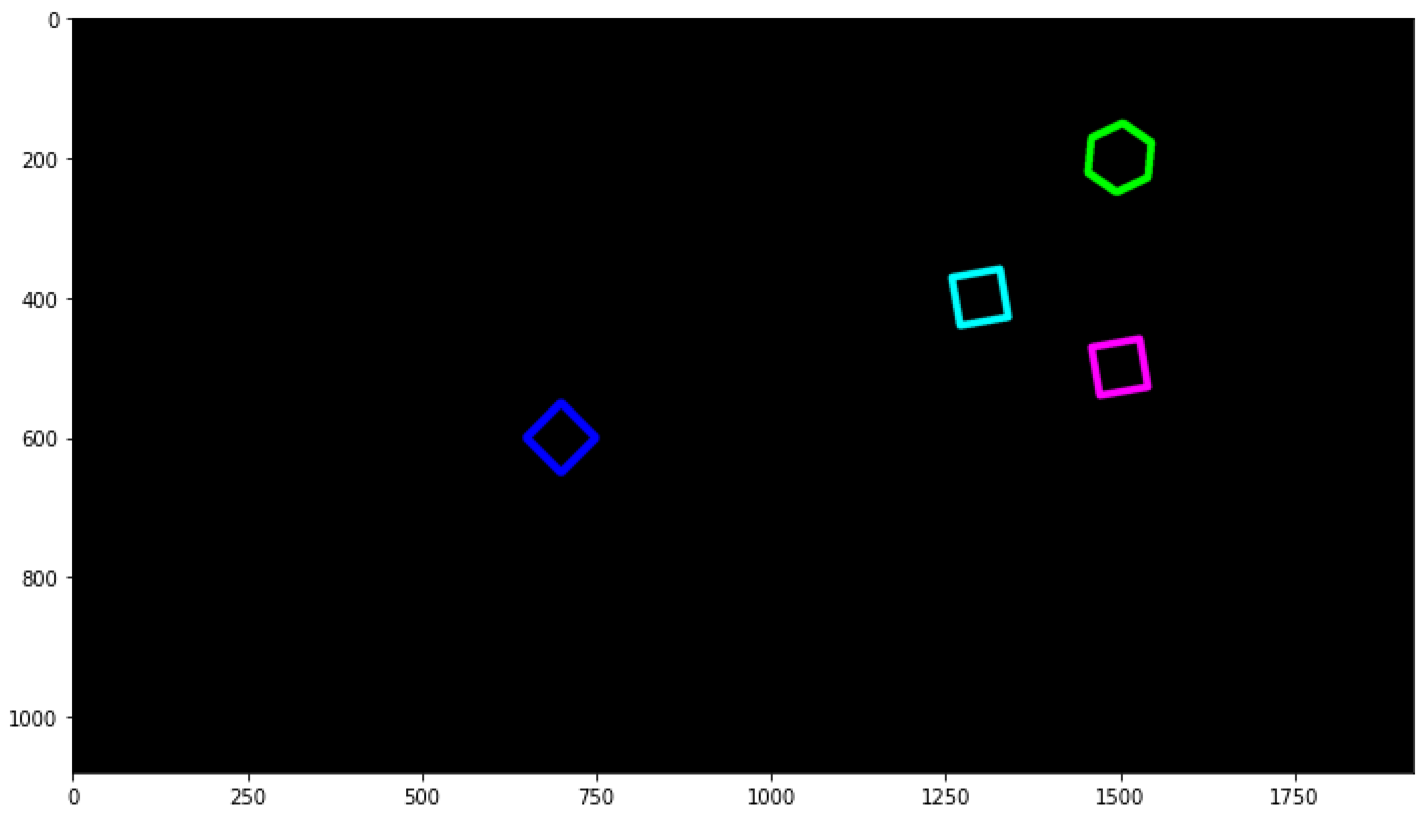
1. Contour analysis: Use `findContours` function to retrieve the *extreme outer* contours. (see https://docs.opencv.org/4.5.2/d4/d73/tutorial_py_contours_begin.html for help and https://docs.opencv.org/4.5.2/d3/dc0/group__imgproc__shape.html#gadf1ad6a0b82947fa1fe3c3d497f260e0 for information.

Display these contours. You should see something like the following:

In [ ]:

```python
contours, hierarchy = cv.findContours(conveyor_f100, cv.RETR_EXTERNAL, cv.CHAIN_APPROX_SIMPLE)
con_copy = cv.cvtColor(conveyor_f100.copy(), cv.COLOR_GRAY2BGR)
```

```
con_copy_ = np.zeros(con_copy.shape, dtype=int)
for i in range(len(contours)):
    cv.drawContours(con_copy_, contours, i,(np.random.randint(2)*255,np.random.randint(2)*255,np.random.randint(2)*255)
fig, ax = plt.subplots(figsize=(12,10))
ax.imshow(con_copy_)
plt.show()
```



Detecting Objects on a Synthetic Conveyor

In this section, we will use the synthetic `conveyor.mp4` sequence to count the two types of nuts.

1. Open the sequence and play it using the code below.

In [ ]:

```
cv.namedWindow('Conveyor', cv.WINDOW_NORMAL)
cap = cv.VideoCapture(r'Assignment-03 Materials\conveyor.mp4')
f = 0
frame = []
while cap.isOpened():
    ret, frame = cap.read()
    if not ret:
        print("Can't receive frame (stream end?). Exiting.")
        break

    f += 1
    text = 'Frame:' + str(f)
    cv.putText(frame,text , (100, 100), cv.FONT_HERSHEY_COMPLEX, 1, (0,250,0), 1, cv.LINE_AA)
    cv.imshow('Conveyor', frame)

    if cv.waitKey(1) == ord('q'):
        break

cap.release()
cv.destroyAllWindows()
```

```
Can't receive frame (stream end?). Exiting.
```

1. Count the number of matching hexagonal nuts in `conveyor_f100.png`. You can use `matchCountours` function as shown in https://docs.opencv.org/4.5.2/d5/d45/tutorial_py_contours_more_functions.html to match contours in each frame with that in th template.

In [ ]:

```
contours1,hierarchy1 = cv.findContours(hexnut_template, cv.RETR_EXTERNAL, cv.CHAIN_APPROX_SIMPLE)
contours2,hierarchy2 = cv.findContours(conveyor_f100, cv.RETR_EXTERNAL, cv.CHAIN_APPROX_SIMPLE)
count = 0
for i in range(len(contours2)):
    ret = cv.matchShapes(contours1[0],contours2[i],1,0.0)
    if ret < 0.002:
        count+=1

print("No of matching hexagonal nuts =",count)
```

```
No of matching hexagonal nuts = 1
```

1. Count the number of objects that were conveyed along the conveyor belt: Display the count in the current frame and total count upto the current frame in the output video. Please compress your video (using Handbreak or otherwise) before uploading. It would be good to experiment first with the two adjacent frames `conveyor_f100.png` and `conveyor_f101.png`. In order to disregard partially appearing nuts, consider comparing the contour area in addition to using the `matchCountours` function.

In [ ]:

```
# this function counts the number of hexagonal nuts & square nuts in a given frame
# & returns those values
# in addition to that it increments the total hexagonal nuts global variable &
# the total square nuts global variable accordingly
```

```
'''Overall operation : At the 1st frame. All nuts are counted. The right-most nut is taken as
    the refernce and its position is followed on the belt. Once a new nut comes from right side,
    the function finds out the type of that nut and increments the counter variables accordingly.
    Then, the new reference is the newest right-most nut. This procedure is repeated till the last frame'''

def objCount(hex_con, sqr_con, vid_frame):
    global tot_hex_count
    global tot_sqr_count
    global border
    ret_,vid_frame = cv.threshold(cv.cvtColor(vid_frame,cv.COLOR_BGR2GRAY),0,255,cv.THRESH_OTSU)
    vid_frame = np.invert(vid_frame)
    kernel = np.ones((3,3), np.uint8)
    vid_frame = cv.morphologyEx(vid_frame, cv.MORPH_CLOSE, kernel)
    conts, hier = cv.findContours(vid_frame, cv.RETR_EXTERNAL, cv.CHAIN_APPROX_SIMPLE)

    hex_count, sqr_count = 0,0
    bborder = 0
    for i in range(len(conts)):
        center = min(conts[i][:,0,0])
        ret_hex = cv.matchShapes(hex_con[0],conts[i],1,0.0)
        ret_sqr = cv.matchShapes(sqr_con[0],conts[i],1,0.0)
        if ret_hex < 0.0015:
            hex_count+=1
            if bborder < center:bborder = center
            if center > border:tot_hex_count += 1
        if ret_sqr < 0.0015:
            sqr_count+=1
            if bborder < center:bborder = center
            if center > border:tot_sqr_count += 1

    if any([hex_count,sqr_count]):
        border = bborder

    return hex_count, sqr_count
```

In [ ]:

```
# Yor code here.

frame_array = []
shape = (1080, 1920, 3)

contours_hex, hierarchy_hex = cv.findContours(hexnut_template, cv.RETR_EXTERNAL, cv.CHAIN_APPROX_SIMPLE)
contours_sqr, hierarchy_sqr = cv.findContours(squarenut_template, cv.RETR_EXTERNAL, cv.CHAIN_APPROX_SIMPLE)
tot_hex_count, tot_sqr_count, border = 0, 0, 0

cv.namedWindow('Conveyor', cv.WINDOW_NORMAL)
cap = cv.VideoCapture(r'Assignment-03 Materials\conveyor.mp4')
f = 0
frame = []
while cap.isOpened():
    ret, frame = cap.read()
    if not ret:
        print("Can't receive frame (stream end?). Exiting.")
        break

    hx, sqr = objCount(contours_hex, contours_sqr, frame)

    f += 1
    txt1 = 'Frame:' + str(f)
    txt2 = "Hexagonal Nuts count in the current frame = " + str(hx)
    txt3 = "Square Nuts count in the current frame = " + str(sqr)
    txt4 = "Total Hexagonal Nuts count upto the current frame = " + str(tot_hex_count)
    txt5 = "Total Square Nuts count upto the current frame = " + str(tot_sqr_count)
    cv.putText(frame,txt1 , (100, 50), cv.FONT_HERSHEY_COMPLEX, 1, (0,250,0), 1, cv.LINE_AA)
    cv.putText(frame,txt2 , (100, 100), cv.FONT_HERSHEY_COMPLEX, 1, (250,0,0), 1, cv.LINE_AA)
    cv.putText(frame,txt3 , (100, 150), cv.FONT_HERSHEY_COMPLEX, 1, (250,0,0), 1, cv.LINE_AA)
    cv.putText(frame,txt4 , (100, 200), cv.FONT_HERSHEY_COMPLEX, 1, (250,0,0), 1, cv.LINE_AA)
    cv.putText(frame,txt5 , (100, 250), cv.FONT_HERSHEY_COMPLEX, 1, (250,0,0), 1, cv.LINE_AA)
    cv.imshow('Conveyor', frame)
    frame_array.append(frame)
    if cv.waitKey(1) == ord('q'):
        break

cap.release()
cv.destroyAllWindows()

# Writing the video

out = cv.VideoWriter('./conveyor_result_190648C.mp4',cv.VideoWriter_fourcc(*'h264'), 30, (shape[1], shape[0]))

for i in range(len(frame_array)):
    cv.imshow('Frame', frame_array[i])
    if cv.waitKey(1) == ord('q'):
        break
    out.write(frame_array[i])

out.release()
cv.destroyAllWindows()
```

```
Can't receive frame (stream end?). Exiting.
```