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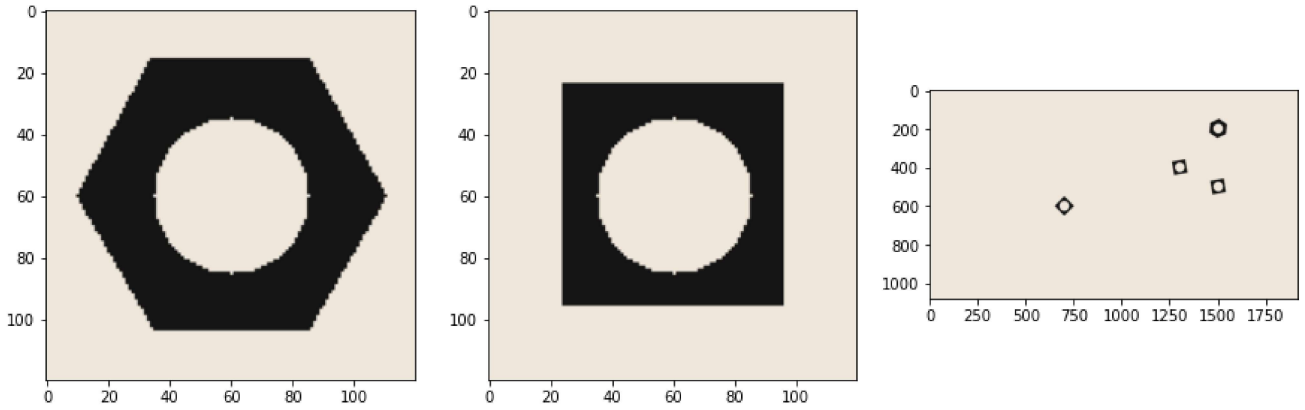
Index number : 190144D
Assignment 3 on Object Counting on a Conveyor Belt

Github: https://github.com/pramodj196/EN2550-Fundamentals-of-Image-Processing-and-Machine-Vision/tree/main/Assignment%203

Connected Component Analysis

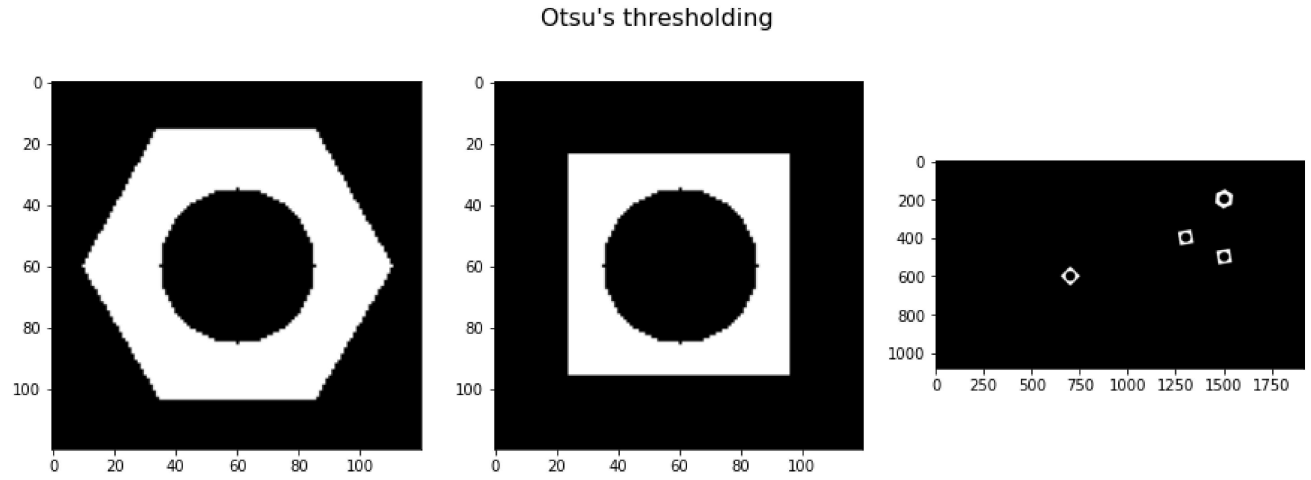
In [ ]:
```
import cv2 as cv
import numpy as np
import matplotlib.pyplot as plt

hexnut_template = cv.imread('hexnut_template.png', cv.IMREAD_COLOR)
squarenut_template =  cv.imread('squarenut_template.png', cv.IMREAD_COLOR)
conveyor_f100 =  cv.imread('conveyor_f100.png', cv.IMREAD_COLOR)

fig, ax = plt. subplots(1,3,figsize=(15, 5))
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()
```



Thresholding

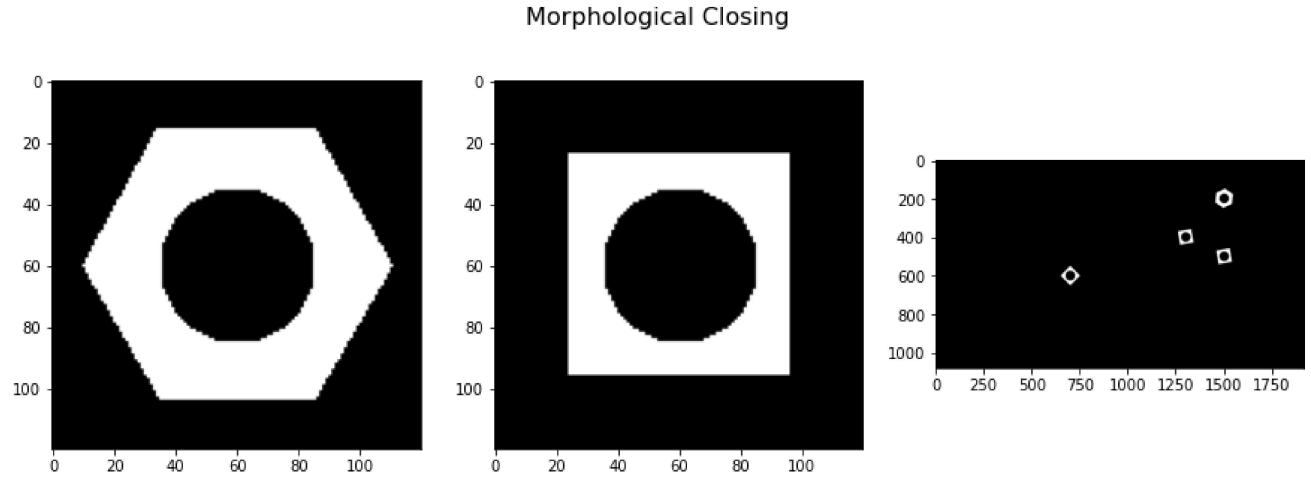
In [ ]:
```
hexnut_template_gry = cv.cvtColor(hexnut_template,cv.COLOR_BGR2GRAY)
squarenut_template_gry = cv.cvtColor(squarenut_template,cv.COLOR_BGR2GRAY)
conveyor_f100_gry = cv.cvtColor(conveyor_f100,cv.COLOR_BGR2GRAY)

ret1,th1 = cv.threshold(hexnut_template_gry ,0,255,cv.THRESH_BINARY_INV+cv.THRESH_OTSU)
ret2,th2= cv.threshold(squarenut_template_gry ,0,255,cv.THRESH_BINARY_INV+cv.THRESH_OTSU)
ret3,th3 = cv.threshold(conveyor_f100_gry,0,255,cv.THRESH_BINARY_INV+cv.THRESH_OTSU)

print("hexnut_template threshold : ",ret1)
print("squarenut_template threshold : ",ret2)
print("conveyor_f100 threshold : ",ret3)

fig, ax = plt.subplots(1, 3, figsize=(15, 5))
fig.suptitle("Otsu's thresholding", fontsize=16)
ax[0].imshow(th1, cmap='gray')
ax[1].imshow(th2, cmap='gray')
ax[2].imshow(th3, cmap='gray')
plt.show()
```

```
hexnut_template threshold :  20.0
squarenut_template threshold :  20.0
conveyor_f100 threshold :  20.0
```



Morphological Closing

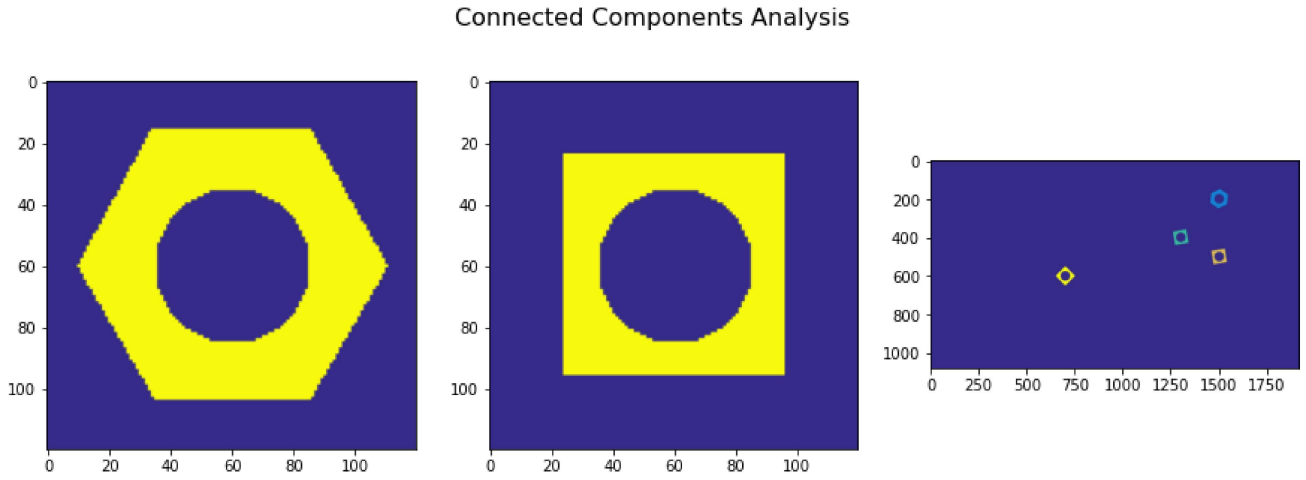
In [ ]:
```
kernel = np.ones((3, 3), np.uint8)
hexnut_closed = cv.morphologyEx(th1, cv.MORPH_CLOSE, kernel)
squarenut_closed = cv.morphologyEx(th2, cv.MORPH_CLOSE, kernel)
conveyor_f100_closed = cv.morphologyEx(th3, cv.MORPH_CLOSE, kernel)
fig, ax = plt.subplots(1, 3, figsize=(15, 5))
fig.suptitle("Morphological Closing", fontsize=16)
ax[0].imshow(hexnut_closed, cmap='gray')
ax[1].imshow(squarenut_closed, cmap='gray')
ax[2].imshow(conveyor_f100_closed, cmap='gray')
plt.show()
```



Connected Components Analysis

In [ ]:
```
hexnut_retval, hexnut_labels, hexnut_stats, hexnut_centroids = cv.connectedComponentsWithStats(hexnut_closed)
squarenut_retval, squarenut_labels, squarenut_stats, squarenut_centroids = cv.connectedComponentsWithStats(square
conveyor_f100_retval, conveyor_f100_labels, conveyor_f100_stats, conveyor_f100_centroids = cv.connectedComponents
hexnut_colormap = cv.applyColorMap((hexnut_labels/np.amax(hexnut_labels)*255).astype('uint8'), cv.COLORMAP_PARULA
squarenut_colormap = cv.applyColorMap((squarenut_labels/np.amax(squarenut_labels)*255).astype('uint8'), cv.COLORM
conveyor_f100_colormap = cv.applyColorMap((conveyor_f100_labels/np.amax(conveyor_f100_labels)*255).astype('uint8'
fig, ax = plt.subplots(1, 3, figsize=(15, 5))
fig.suptitle("Connected Components Analysis", fontsize=16)
ax[0].imshow(cv.cvtColor(hexnut_colormap, cv.COLOR_BGR2RGB))
ax[1].imshow(cv.cvtColor(squarenut_colormap, cv.COLOR_BGR2RGB))
ax[2].imshow(cv.cvtColor(conveyor_f100_colormap, cv.COLOR_BGR2RGB))
plt.show()

print('-'*90)
print("{:>22}{:>22}{:>42}".format("Hexnut Objects", "Area", "Centroid"))
for i in range(hexnut_retval):
    print("{:>22}{:>22}{:>42}".format("Background" if i == 0 else "Object " + str(i), hexnut_stats[i][cv.CC_STAT_
print('-'*90)
```

```
print("{:>22}{:>22}{:>42}".format("Squarenut Objects", "Area", "Centroid"))
for i in range(squarenut_retval):
    print("{:>22}{:>22}{:>42}".format("Background" if i == 0 else "Object " + str(i), squarenut_stats[i][cv.CC_ST
print('-'*90)
print("{:>22}{:>22}{:>42}".format("Conveyor_f100 Objects", "Area", "Centroid"))
for i in range(conveyor_f100_retval):
    print("{:>22}{:>22}{:>42}".format("Background" if i == 0 else "Object " + str(i), conveyor_f100_stats[i][cv.C
print('-'*90)
```




```
------------------------------------------------------------------------------------------
       Hexnut Objects                  Area                                  Centroid
           Background                  9672                 [59.33684864 59.63513234]
             Object 1                  4728                 [59.83375635 59.22356176]
------------------------------------------------------------------------------------------
     Squarenut Objects                  Area                                  Centroid
           Background                 11173                   [59.5875772 59.5875772]
             Object 1                  3227                 [59.19677719 59.19677719]
------------------------------------------------------------------------------------------
 Conveyor_f100 Objects                  Area                                  Centroid
           Background               2059646              [957.36323524 540.44416273]
             Object 1                  4636            [1499.24201898  199.28515962]
             Object 2                  3087            [1299.18302559  399.18302559]
             Object 3                  3087            [1499.18302559  499.18302559]
             Object 4                  3144                           [700. 600.]
------------------------------------------------------------------------------------------
```

In the hexnut and squarenut images, we get total 2 connected components and in the conveyor_f100 image we get 5 connected components. In each image, background is assigned as label 0.
Statistics are the properties of each connected componnets. There are 5 properties we can get from this list.

- **CC_STAT_LEFT : The leftmost (x) coordinate which is the inclusive start of the bounding box in the horizontal direction.**
- **CC_STAT_TOP : The topmost (y) coordinate which is the inclusive start of the bounding box in the vertical direction.**
- **CC_STAT_WIDTH : The horizontal size of the bounding box.**
- **CC_STAT_HEIGHT : The vertical size of the bounding box.**
- **CC_STAT_AREA : The total area (in pixels) of the connected component.**

Centroids are the center cordinates of each connected contours.

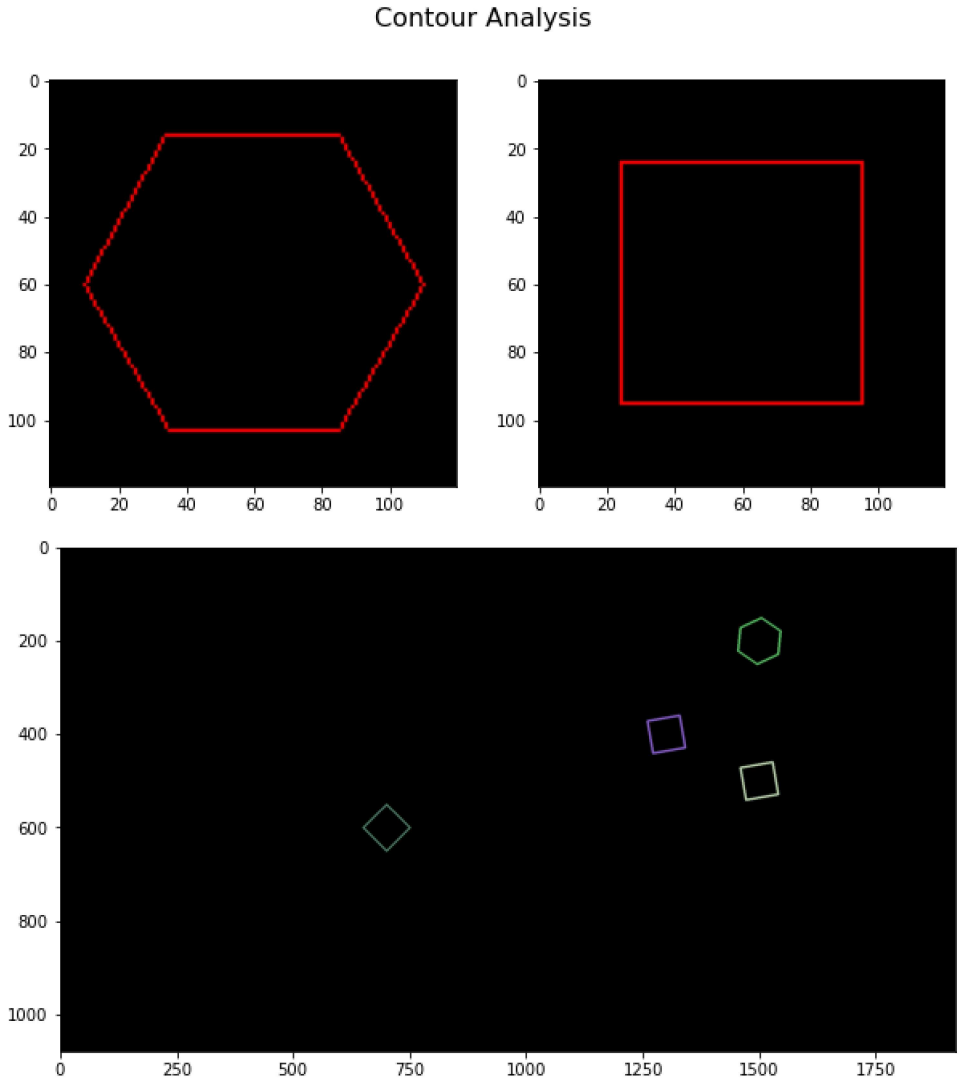
As you can see from the table above, the area of the hexnut is about 4728 and the area of the squarenut is about 3227. We can also see that the conveyor_f100 image has one hexnut and 3 squarenuts. This can also be seen in object areas. Object1 has 4636 area close to the hexnut area and each of the other 3 objects have an area close to the squarenut area.

Contour Analysis

In [ ]:

```
import random as rng
hexnut_contours, hexnut_template_hierarchy= cv.findContours(hexnut_closed, cv.RETR_EXTERNAL, cv.CHAIN_APPROX_SIMP
hexnut_contour = hexnut_contours[0] # contour corresponding to hexnut

squarenut_contours, squarenut_template_hierarchy= cv.findContours(squarenut_closed, cv.RETR_EXTERNAL, cv.CHAIN_AP
squarenut_contour = squarenut_contours[0] # contour corresponding to squarenut
```

```
conveyor_f100_contours, conveyor_f100_contours_hierarchy= cv.findContours(conveyor_f100_closed, cv.RETR_EXTERNAL,

img_hexnut = np.zeros(hexnut_template.shape, dtype=np.uint8)
cv.drawContours(img_hexnut, hexnut_contours, -1, (0, 0, 255))
img_squarenut = np.zeros(hexnut_template.shape, dtype=np.uint8)
cv.drawContours(img_squarenut, squarenut_contours, -1, (0, 0, 255))
img_conveyor = np.zeros(conveyor_f100.shape, dtype=np.uint8)
for i in range(len(conveyor_f100_contours)):
    color = (rng.randint(50,256), rng.randint(50,256), rng.randint(50,256))
    cv.drawContours(img_conveyor, conveyor_f100_contours, i, color, 3) # applying random color for each contour

fig, ax = plt.subplots(1, 2, figsize=(10, 5))
fig.suptitle("Contour Analysis", fontsize=16)
ax[0].imshow(cv.cvtColor(img_hexnut, cv.COLOR_BGR2RGB))
ax[1].imshow(cv.cvtColor(img_squarenut, cv.COLOR_BGR2RGB))
plt.show()
fig, ax = plt. subplots(figsize=(10, 10))
ax.imshow(cv.cvtColor(img_conveyor, cv.COLOR_BGR2RGB))
plt.show()
```



Detecting Objects on a Synthetic Conveyor

Playing Video

In [ ]:

```
cv.namedWindow('Conveyor', cv.WINDOW_NORMAL)
cap = cv.VideoCapture('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.
```

Count the number of matching hexagonal nuts and square nuts

In [ ]:

```
hexnut_count,squarenut_count = 0,0
for cnt in conveyor_f100_contours:
    ret1 = cv.matchShapes(cnt,hexnut_contour,1,0.0)
    ret2 = cv.matchShapes(cnt,squarenut_contour,1,0.0)
    if (ret1 < 0.001): #0.001 as the thresholding value
        hexnut_count+=1
    if (ret2 < 0.001): #0.001 as the thresholding value
        squarenut_count+=1
print("Number of hexagonal nuts in conveyor_f100 image :", hexnut_count)
print("Number of square nuts in conveyor_f100 image :", squarenut_count)
```

```
Number of hexagonal nuts in conveyor_f100 image : 1
Number of square nuts in conveyor_f100 image : 3
```

Count the number of objects that were conveyed along the conveyor belt

1. **First, threshold the frame, carry out morphology, and then find the contours as did in above.**
2. **Compare the contour area in order to disregard partially appearing nuts and match the contours using cv.matchShapes() with hexnut or squarenut.**
3. **After identifying the correct contour, append its y-coordinate (horizontal) to contour_y dictionary.**
4. **Then, for each y-coordinate in contour_y , if the y-coordinate is greater than the previous maximum, increment the total count by 1.**
5. **Update the maximum_y .**

In [ ]:

```
frame_array = []
shape = (1080, 1920, 3)
cap = cv.VideoCapture('conveyor.mp4')
maximum_y = {'hexnut':0, 'squarenut':0} # dictionary for store the maximum y-distance (horizontal) in previous fr
total = {'hexnut':0, 'squarenut':0} # dictionary for stores the total each nuts
while cap.isOpened():
    ret, frame = cap.read()
    if not ret:
        print("Can't receive frame (stream end?). Exiting.")
        break
    conveyor_ret, conveyor_thresh = cv.threshold(cv.cvtColor(frame, cv.COLOR_BGR2GRAY), 0, 255, cv.THRESH_BINARY_
    conveyor_closed = cv.morphologyEx(conveyor_thresh, cv.MORPH_CLOSE, kernel)
    conveyor_contours, conveyor_contours_hierarchy= cv.findContours(conveyor_closed, cv.RETR_EXTERNAL, cv.CHAIN_A
    cv.drawContours(frame, conveyor_contours, -1, (0,255,0), 3)
    contour_y = {'hexnut':[], 'squarenut':[]}
    count = {'hexnut':0, 'squarenut':0}
    for cnt in conveyor_contours:
        ret = cv.matchShapes(cnt, hexnut_contour, 1, 0.0)
        if (ret < 0.001):
            M = cv.moments(cnt)
            if (M['m00']>5000):
                count['hexnut'] += 1
                contour_y['hexnut'].append(int(M['m10']/M['m00']))
        ret = cv.matchShapes(cnt, squarenut_contour, 1, 0.0)
```

```
        if (ret < 0.001):
            M = cv.moments(cnt)
            if (M['m00']>3000):
                count['squarenut'] += 1
                contour_y['squarenut'].append(int(M['m10']/M['m00']))

    frame_maximum = {'hexnut':0, 'squarenut':0}
    for nut in ['hexnut','squarenut']:
        for y in contour_y[nut]:
            frame_maximum[nut] = max(frame_maximum[nut], y)
            if maximum_y[nut] < y:
                total[nut] += 1
        maximum_y[nut] = frame_maximum[nut]
    text = 'Hexnut count in frame = ' + str(count['hexnut']) + " Total hexnutnuts = " + str(total['hexnut'])
    cv.putText(frame, text , (100, 50), cv.FONT_HERSHEY_COMPLEX, 1, (0, 0, 255), 1, cv.LINE_AA)
    text = 'Squarenut count in frame = ' + str(count['squarenut']) + " Total squarenut nuts = " + str(total['squa
    cv.putText(frame, text , (100, 100), cv.FONT_HERSHEY_COMPLEX, 1, (0, 0, 255), 1, cv.LINE_AA)
    text = 'Total nuts = ' + str(total['hexnut'] + total['squarenut'])
    cv.putText(frame, text , (100, 150), cv.FONT_HERSHEY_COMPLEX, 1, (255, 0, 0), 1, cv.LINE_AA)
    frame_array.append(frame)
cap.release()
out = cv.VideoWriter('./conveyor_result_190144D.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.
```