190501V - Ranathunga R.A.C.D.

Github link :
https://github.com/ChamithDilshan/EN2550_Image_processing_and_machine_vision/tree/main/Assignments/Assignment

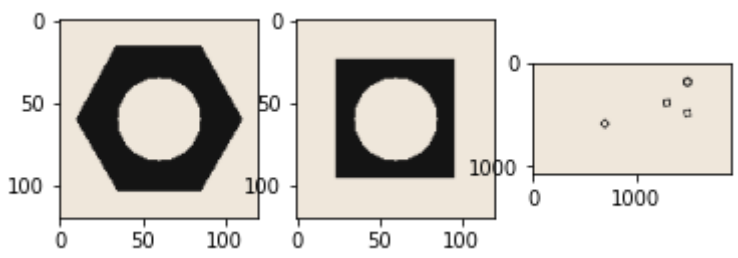
EN2550: Assignment 03 on Object Counting on a Conveyor Belt

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.

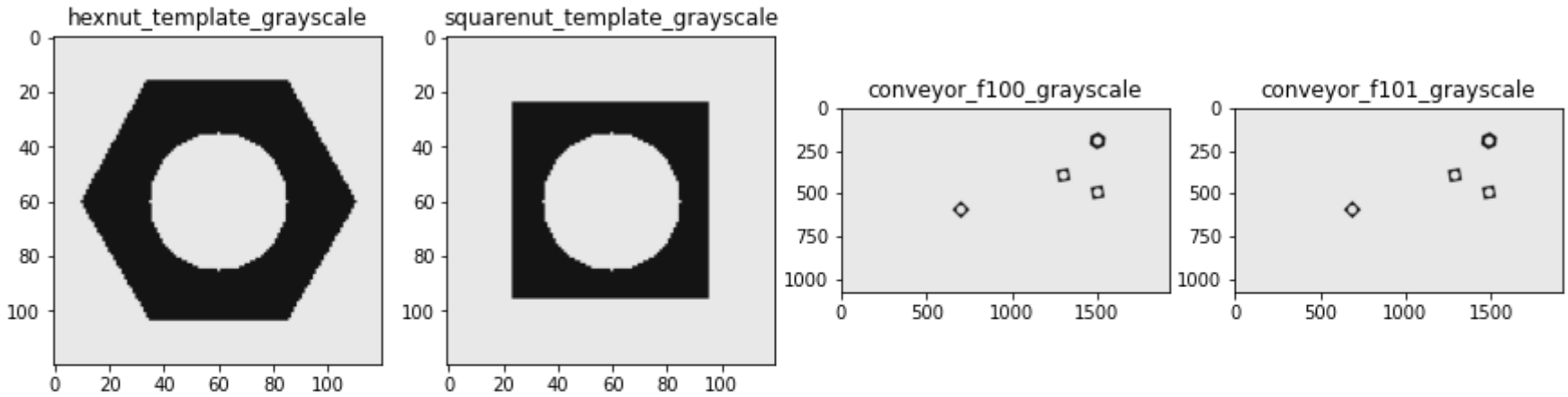
In [2]:
```
import cv2 as cv
import numpy as np
import matplotlib.pyplot as plt

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)
conveyor_f101 =  cv.imread('conveyor_f101.png', cv.IMREAD_COLOR)

fig, ax = plt. subplots(1,3)
ax[0].imshow(cv.cvtColor(hexnut_template, cv.COLOR_BGR2RGB))
ax[1].imshow(cv.cvtColor(squarenut_template, cv.COLOR_BGR2RGB))
ax[2].imshow(cv.cvtColor(conveyor_f100, cv.COLOR_BGR2RGB))
plt.show()
```

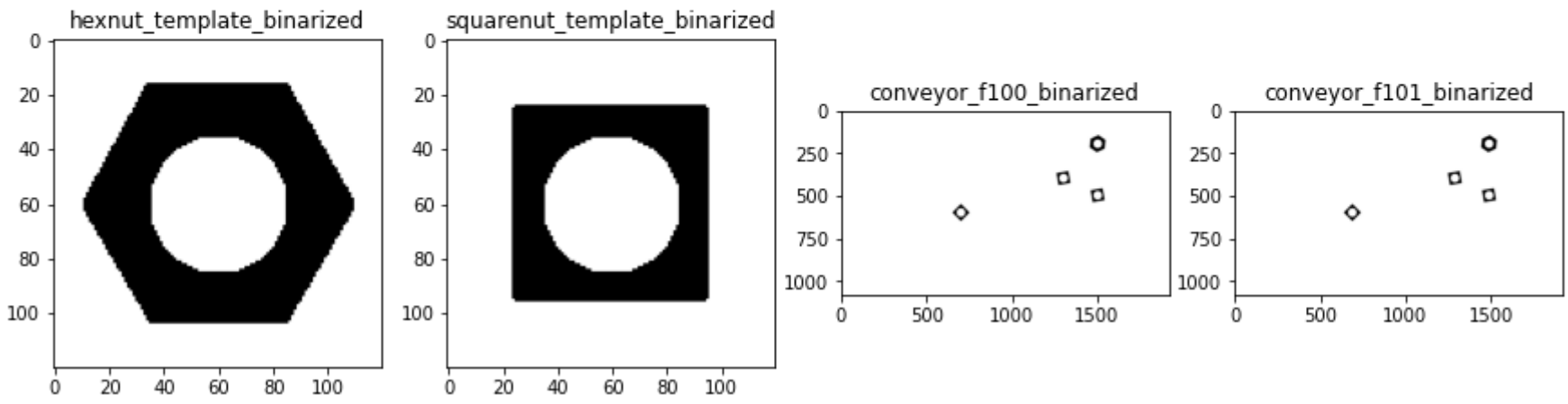


Convert the images to grayscale and apply Otsu's thresholding to obtain the binarized image. Do this for both the templates and belt images. State the threshold value (automatically) selected in the operation. Display the output images.

In [3]:
```
images = [hexnut_template, squarenut_template, conveyor_f100, conveyor_f101]
titles = ["hexnut_template", "squarenut_template", "conveyor_f100", "conveyor_f101"]
binarized_images = []

fig,ax = plt.subplots(2,4, figsize = (15,15))

for i in range(len(images)):
    gray_image = cv.cvtColor(images[i], cv.COLOR_BGR2GRAY)
    blur = cv.GaussianBlur(gray_image,(5,5),0)
    threshold_value, binary_image = cv.threshold(blur,0,255,cv.THRESH_BINARY+cv.THRESH_OTSU)

    binarized_images.append(binary_image) #Because later we want to call these images
    ax[0,i].imshow(cv.cvtColor(gray_image, cv.COLOR_BGR2RGB)) ; ax[0,i].set_title(titles[i]+"_grayscale")
    ax[1,i].imshow(cv.cvtColor(binary_image, cv.COLOR_BGR2RGB)) ; ax[1,i].set_title(titles[i]+"_binarized")
    print("Threshold for %s is %s"%(titles[i], threshold_value))
plt.show()
```

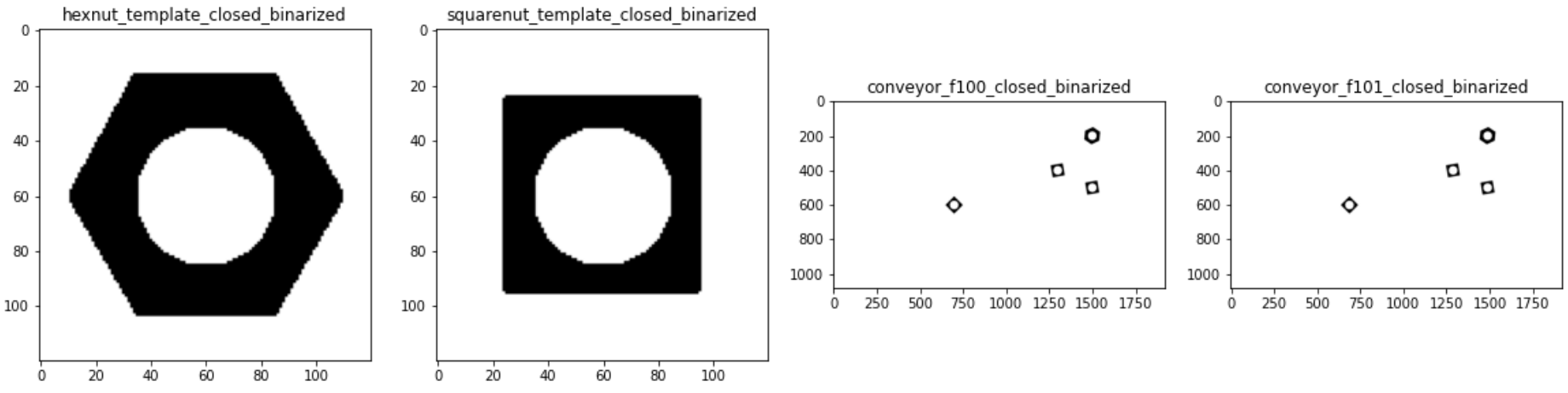
```
Threshold for hexnut_template is 116.0
Threshold for squarenut_template is 116.0
Threshold for conveyor_f100 is 128.0
Threshold for conveyor_f101 is 128.0
```





1. Carry out morphological closing to remove small holes inside the foreground. Use a 3 × 3 kernel.

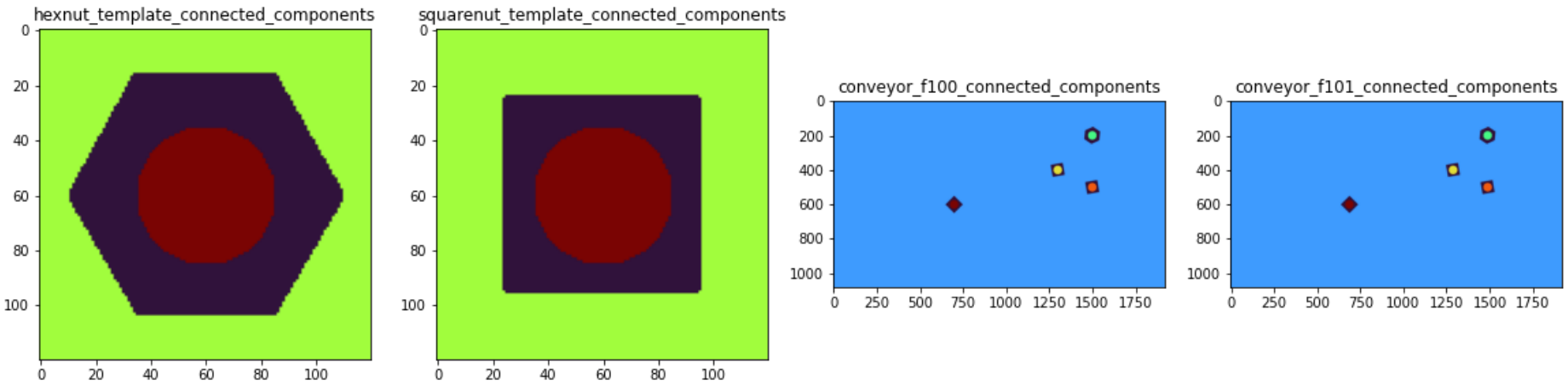
In [4]:
```
kernel = np.ones((3,3),np.uint8)
closed_binarized_images = []

fig, ax = plt.subplots(1,4, figsize = (20,20))

for i in range(len(images)):
    closing = cv.morphologyEx(binarized_images[i], cv.MORPH_CLOSE, kernel)
    closed_binarized_images.append(closing)
    ax[i].imshow(cv.cvtColor(closing, cv.COLOR_BGR2RGB))
    ax[i].set_title(titles[i]+"_closed_binarized")
plt.show()
```



Connected components analysis.

In [5]:
```
connected_components = []
fig, ax = plt.subplots(1,4,figsize = (20,20))

for i in range(4):
    retbal, labels, stats, centroids = cv.connectedComponentsWithStats(closed_binarized_images[i])
    colormapped = cv.applyColorMap((labels/np.amax(labels)*255).astype('uint8'), cv.COLORMAP_TURBO)
    connected_components.append(colormapped)
    ax[i].imshow(cv.cvtColor(colormapped,cv.COLOR_BGR2RGB))
    ax[i].set_title(titles[i]+"_connected_components")
    print(titles[i])
    print("Number of connected components in %s is %s."%(titles[i],np.shape(stats)[0]))
    print("Stats for %s=\n"%(titles[i]), stats)
    print("Centroids are as follows :")
    for j in range(len(centroids)):
        print('--> ', round(centroids[j][0],3),',', round(centroids[j][1],3))
        if j==len(centroids)-1: print('\n')
plt.show()
```

```
hexnut_template
Number of connected components in hexnut_template is 3.
Stats for hexnut_template=
 [[  11   16   99   88 4726]
 [   0    0  120  120 7717]
 [  36   36   49   49 1957]]
Centroids are as follows :
-->  59.834 , 59.223
-->  59.169 , 59.543
-->  60.0 , 60.0


squarenut_template
Number of connected components in squarenut_template is 3.
Stats for squarenut_template=
 [[  24   24   72   72 3223]
 [   0    0  120  120 9220]
 [  36   36   49   49 1957]]
Centroids are as follows :
-->  59.196 , 59.196
-->  59.5 , 59.5
-->  60.0 , 60.0


conveyor_f100
Number of connected components in conveyor_f100 is 6.
Stats for conveyor_f100=
 [[    651     151     895     499   13922]
 [      0       0    1920    1080 2051850]
 [   1476     176      49      49    1957]
 [   1276     376      49      49    1957]
 [   1476     476      49      49    1957]
 [    676     576      49      49    1957]]
Centroids are as follows :
-->  1274.778 , 400.054
-->  956.253 , 540.883
-->  1500.0 , 200.0
-->  1300.0 , 400.0
-->  1500.0 , 500.0
-->  700.0 , 600.0


conveyor_f101
Number of connected components in conveyor_f101 is 6.
Stats for conveyor_f101=
 [[    641     151     895     499   13922]
 [      0       0    1920    1080 2051850]
 [   1466     176      49      49    1957]
 [   1266     376      49      49    1957]
 [   1466     476      49      49    1957]
 [    666     576      49      49    1957]]
Centroids are as follows :
-->  1264.778 , 400.054
-->  956.359 , 540.883
-->  1490.0 , 200.0
-->  1290.0 , 400.0
-->  1490.0 , 500.0
-->  690.0 , 600.0
```

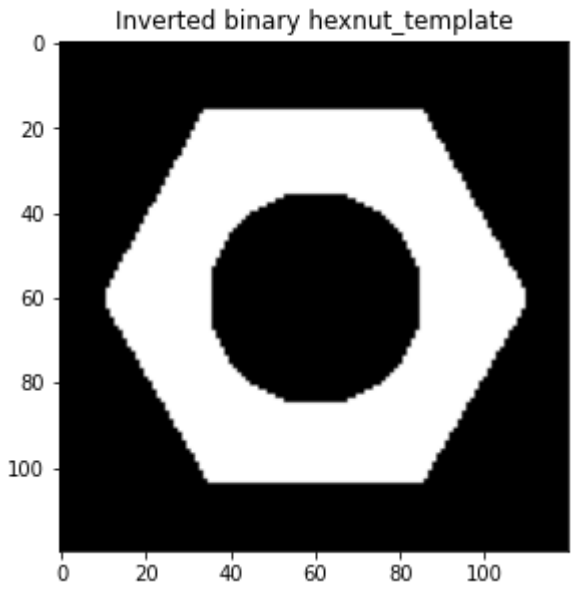


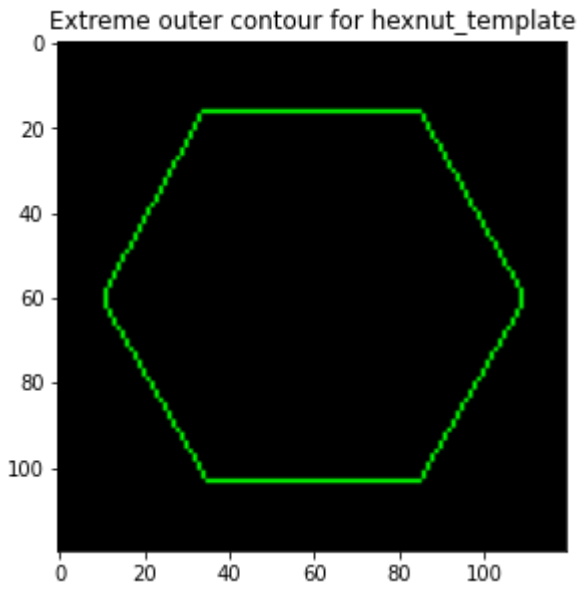
Contour analysis

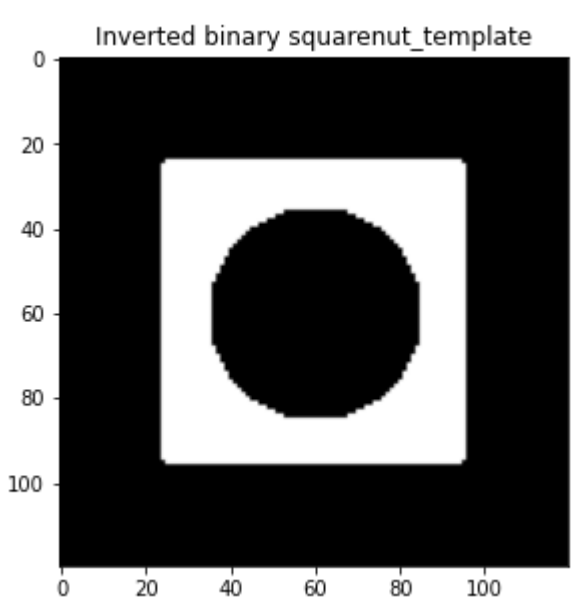
retrieve the extreme outer contours

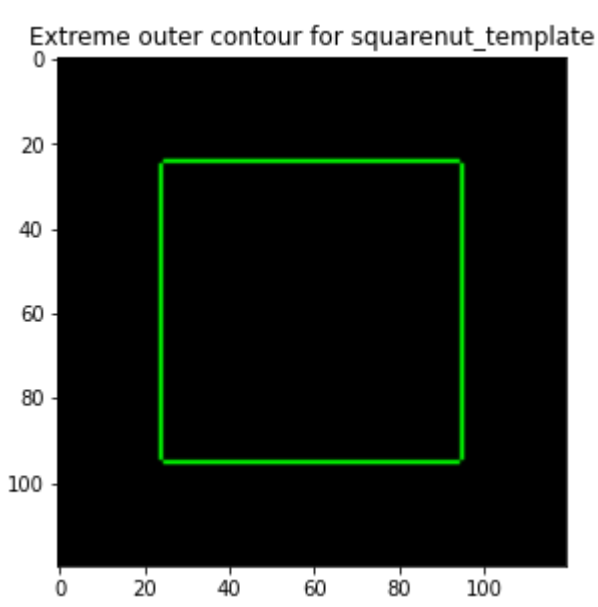
In [10]:
```python
colors = [(0,255,0),(0,0,255),(255,255,0),(255,0,255)]
thicknesses = [1,1,10,10]
contours_list = []

for i in range(4):
    thresh = 255 - closed_binarized_images[i]
    thresh = cv.cvtColor(thresh,cv.COLOR_RGB2BGR)
    thresh = cv.cvtColor(thresh, cv.COLOR_BGR2GRAY)

    cnts = cv.findContours(thresh, cv.RETR_EXTERNAL, cv.CHAIN_APPROX_SIMPLE)
    cnts = cnts[0] if len(cnts) == 2 else cnts[1]
```

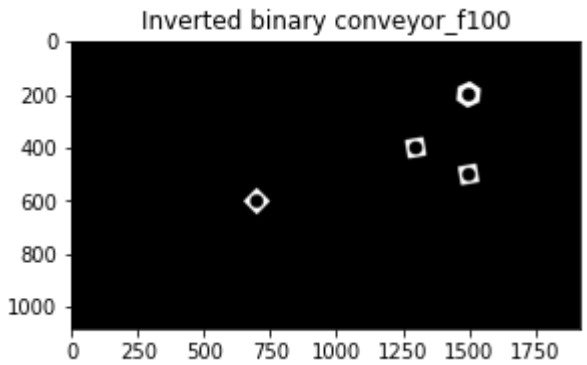
```
    black_background = np.zeros(np.shape(images[i]), dtype='uint8')

    contours_list.append(cnts)

    for j in range(len(cnts)):
        c = cnts[j]
        cv.drawContours(black_background, [c], -1, colors[j], thicknesses[i])

    fig, ax = plt.subplots(1,2, figsize = (10,10))
    ax[0].imshow(cv.cvtColor(thresh, cv.COLOR_RGB2BGR))  ; ax[0].set_title("Inverted binary "+titles[i])
    ax[1].imshow(cv.cvtColor(black_background, cv.COLOR_RGB2BGR)) ; ax[1].set_title("Extreme outer contour for "+titles[i])
    plt.show()
```

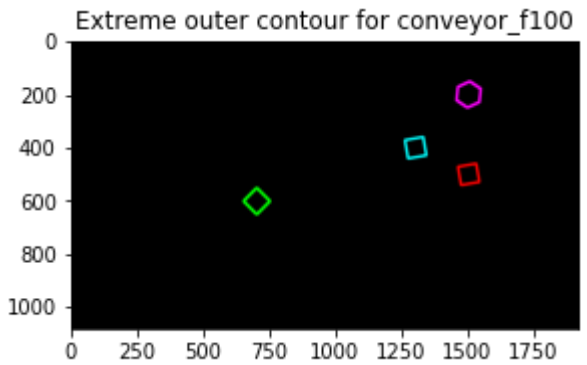


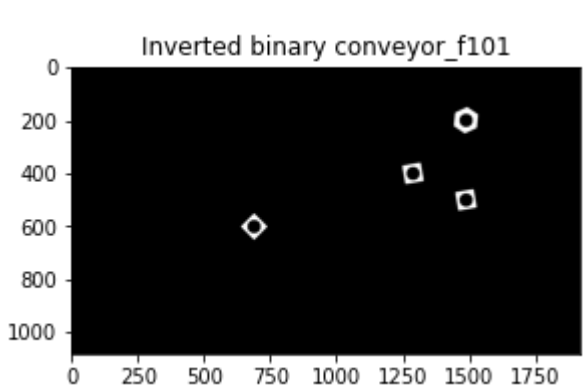


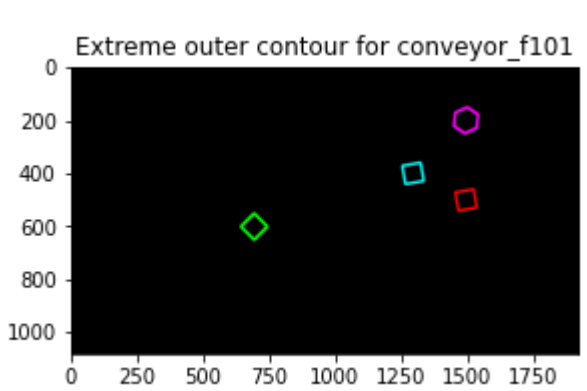












Detecting Objects on a Synthetic Conveyor

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

In [11]:
```
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)
```

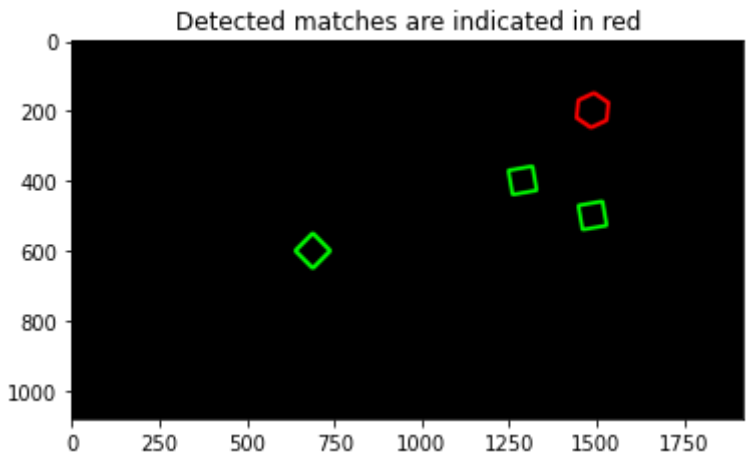
```
    cv.putText(frame,text , (100, 100), cv.FONT_HERSHEY_COMPLEX, 1, (255,0,0), 1, cv.LINE_AA)
    cv.imshow('Conveyor', frame)

    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 in conveyor_f100.png.

In [12]:
```
contours_of_1 = contours_list[0]   #contours related to image 0
contours_of_3 = contours_list[3]   #contours related to image 2

cnt1 = contours_of_1[0]    #image 0 has only one collection

black_background = np.zeros(np.shape(images[2]), dtype='uint8')

detected = 0
for cnt in contours_of_3: #iterate through items in the collection of contours for image 2
    ret = cv.matchShapes(cnt1,cnt,1,0.0)
    print("Matching scores = ",ret )

    if ret <= 0.01:
        detected += 1
        ww = cv.drawContours(black_background, [cnt], -1, [0,0,255], 10)
    else:
        ww = cv.drawContours(black_background, [cnt], -1, [0,255,0], 10)

print("\nDetected %s match(es) of hexagonal nuts in conveyor_f100.png"%(detected))
plt.imshow(cv.cvtColor(ww, cv.COLOR_BGR2RGB)) ; plt.title("Detected matches are indicated in red")
plt.show()
```

```
Matching scores =  0.026486701348536812
Matching scores =  0.025849223429892154
Matching scores =  0.02584922343006335
Matching scores =  9.745595547006047e-06

Detected 1 match(es) of hexagonal nuts in conveyor_f100.png
```



In [13]:
```
contours_of_2 = contours_list[1]   #contours related to image 1
cnt2 = contours_of_2[0]    #image 1 has only one collection
```

In [14]:
```
# cv.namedWindow('Conveyor', cv.WINDOW_NORMAL)
# cv.namedWindow('Result', cv.WINDOW_NORMAL)
cap = cv.VideoCapture('conveyor.mp4')
f = 0
frame = []
kernel = np.ones((5,5),np.uint8)

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

sum_hex , sum_sqr = 0,0
prev_hex , prev_sqr = 0,0

while cap.isOpened():
    ret, frame = cap.read()
    if not ret:
        print("Can't receive frame (stream end?). Exiting.")
        break

    f += 1

    gray_frame = cv.cvtColor(frame, cv.COLOR_BGR2GRAY)
    blur_frame = cv.GaussianBlur(gray_frame,(5,5),0)
    threshold_value, binary_frame = cv.threshold(blur_frame,0,255,cv.THRESH_BINARY+cv.THRESH_OTSU)

    closed_frame = cv.morphologyEx(binary_frame, cv.MORPH_CLOSE, kernel)
    thresh_frame = 255 - closed_frame
    thresh_frame = cv.cvtColor(thresh_frame,cv.COLOR_RGB2BGR)
    thresh_frame = cv.cvtColor(thresh_frame, cv.COLOR_BGR2GRAY)

    cnts_frame = cv.findContours(thresh_frame, cv.RETR_EXTERNAL, cv.CHAIN_APPROX_SIMPLE)
    cnts_frame = cnts_frame[0] if len(cnts_frame) == 2 else cnts_frame[1]
```

```
    detected_hex, detected_sq = 0,0

    for items in cnts_frame:

        rh = cv.matchShapes(cnt1,items,1,0.0)
        rs = cv.matchShapes(cnt2,items,1,0.0)

        if rh <= 0.01:
            detected_hex += 1
            ww = cv.drawContours(frame, [items], -1, [0,0,255], 10)

        elif rs <= 0.01:
            detected_sq += 1
            ww = cv.drawContours(frame, [items], -1, [0,255,0], 10)

        else:
            ww = cv.drawContours(frame, [items], -1, [255,255,255], 10)

    if f%5==1:
        if detected_hex>prev_hex: sum_hex += detected_hex-prev_hex
        if detected_sq>prev_sqr: sum_sqr += detected_sq-prev_sqr

        prev_sqr = detected_sq
        prev_hex = detected_hex

    cv.putText(frame,"Frame = %s"%(f) , (100, 100), cv.FONT_HERSHEY_COMPLEX, 1, (0,0,0), 1, cv.LINE_AA)
    cv.putText(frame,"Number of Hexnuts = %s"%(detected_hex) , (100, 150), cv.FONT_HERSHEY_COMPLEX, 1, (0,0,255), 1, cv.LINE_AA)
    cv.putText(frame,"Number of Squarenuts = %s"%(detected_sq) , (1000, 150), cv.FONT_HERSHEY_COMPLEX, 1, (0,255,0), 1, cv.LINE_A
    cv.putText(frame,"Total Hexnuts = %s"%(sum_hex) , (100, 200), cv.FONT_HERSHEY_COMPLEX, 1, (0,0,255), 1, cv.LINE_AA)
    cv.putText(frame,"Total Squarenuts = %s"%(sum_sqr) , (1000, 200), cv.FONT_HERSHEY_COMPLEX, 1, (0,255,0), 1, cv.LINE_AA)
    cv.putText(frame,"Ranathunga R.A.C.D. - 190501V" , (100, 1000), cv.FONT_HERSHEY_COMPLEX, 1, (0,0,0), 1, cv.LINE_AA)

    frame_array.append(frame)

out = cv.VideoWriter('./conveyor_result_190501V.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()
cap.release()
```

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

In [15]:
```
! conveyor_result_190501V.mp4
```