EN2550: Assignment 03 on Object Counting on a Conveyor Belt

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Index Number - 190009U

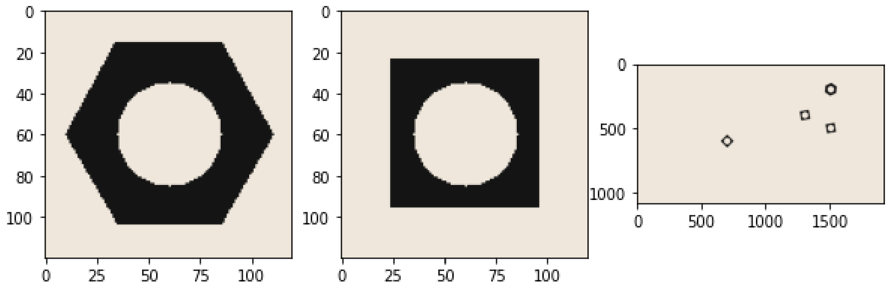
Connected Component Analysis

Question 1

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

In [1]:

```
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=(10,10))
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()
```

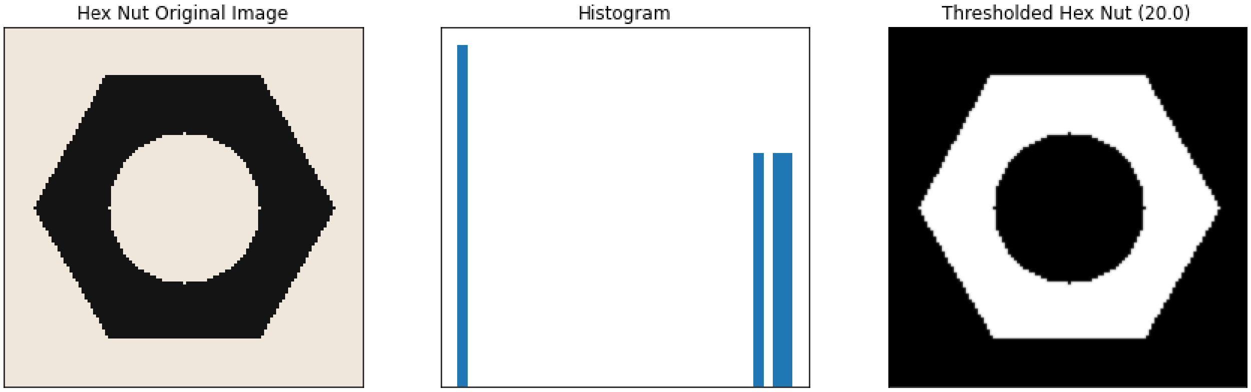


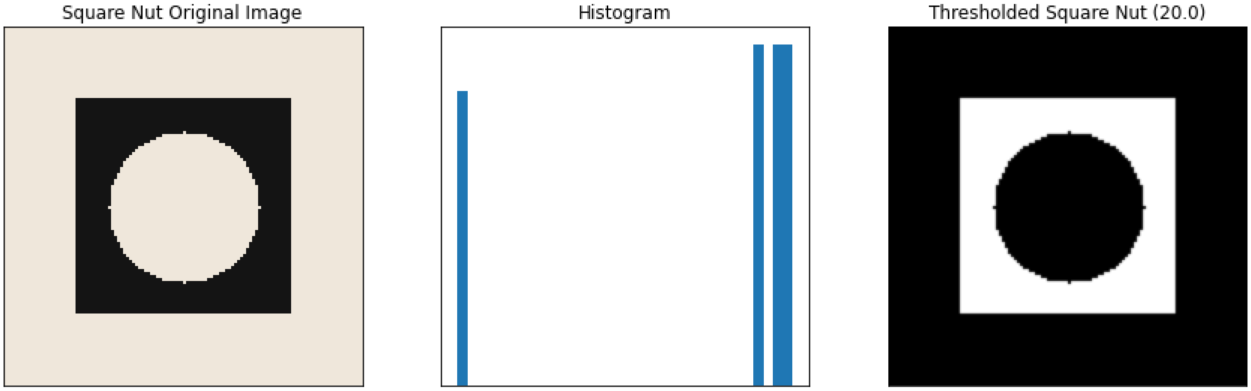
Question 2

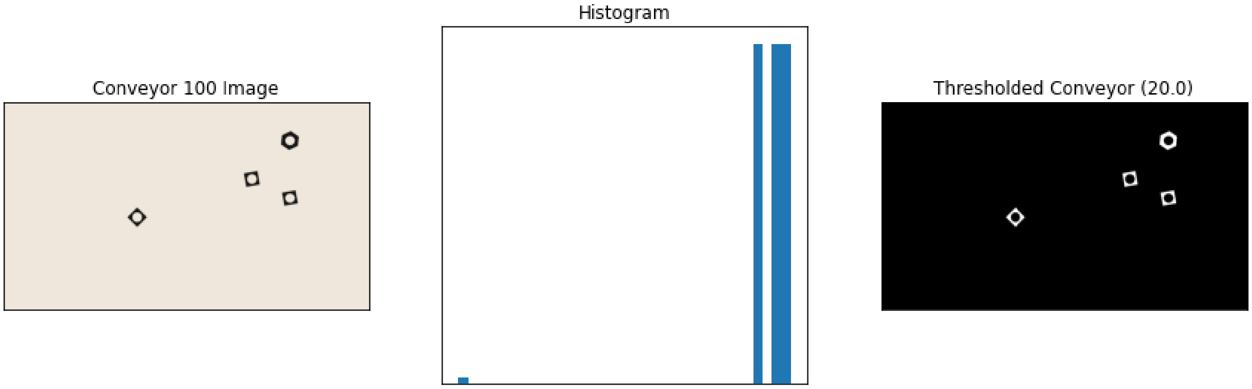
Convert the images to grayscale and apply Otsu's thresholding to obtain the binarized image. Do this for both the templates and belt images. See [https://docs.opencv.org/master/d7/d4d/tutorial_py_thresholding.html (https://docs.opencv.org/master/d7/d4d/tutorial_py_thresholding.html)](https://docs.opencv.org/master/d7/d4d/tutorial_py_thresholding.html)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

In [2]:

```
#Your Code Here
hex_gray = cv.cvtColor(hexnut_template, cv.COLOR_BGR2GRAY)
sqr_gray = cv.cvtColor(squarenut_template, cv.COLOR_BGR2GRAY)
con_100_gray = cv.cvtColor(conveyor_f100, cv.COLOR_BGR2GRAY)

ret_hex, thresh_hex = cv.threshold(hex_gray, 0, 255, cv.THRESH_BINARY_INV + cv.THRESH_OTSU)
ret_sqr, thresh_sqr = cv.threshold(sqr_gray, 0, 255, cv.THRESH_BINARY_INV + cv.THRESH_OTSU)
ret_con_100, thresh_con_100 = cv.threshold(con_100_gray, 0, 255, cv.THRESH_BINARY_INV + cv.THRESH_OTSU)

#The image is inverted because for the detect contours, the object should be white, in a black background.

images = [ hexnut_template, 0, thresh_hex,
           squarenut_template, 0, thresh_sqr,
           conveyor_f100, 0, thresh_con_100]

titles = [ "Hex Nut Original Image", "Histogram", f"Thresholded Hex Nut ({ret_hex})",
           "Square Nut Original Image", "Histogram", f"Thresholded Square Nut ({ret_sqr})",
           "Conveyor 100 Image", "Histogram", f"Thresholded Conveyor ({ret_con_100})"]

for i in range(3):
    plt.figure(figsize=(15,15))
    plt.subplot(3,3,i*3+1), plt.imshow(cv.cvtColor(images[i*3], cv.COLOR_BGR2RGB)),
    plt.title(titles[i*3]), plt.xticks([]), plt.yticks([])

    plt.subplot(3,3,i*3+2), plt.hist(images[i*3].ravel(), 35)
    plt.title(titles[i*3+1]), plt.xticks([]), plt.yticks([])

    plt.subplot(3,3,i*3+3), plt.imshow(cv.cvtColor(images[i*3+2], cv.COLOR_BGR2RGB))
    plt.title(titles[i*3+2]), plt.xticks([]), plt.yticks([])
```





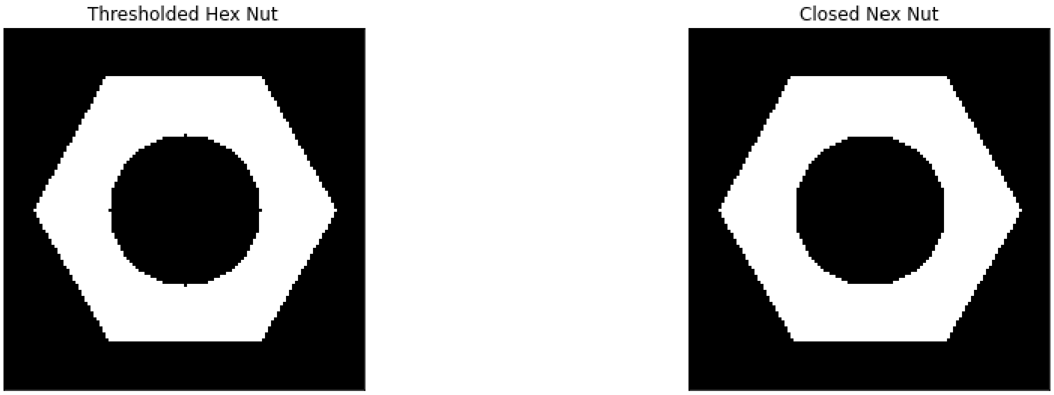


Question 3

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 (https://docs.opencv.org/master/d9/d61/tutorial_py_morphological_ops.html) for a guide.

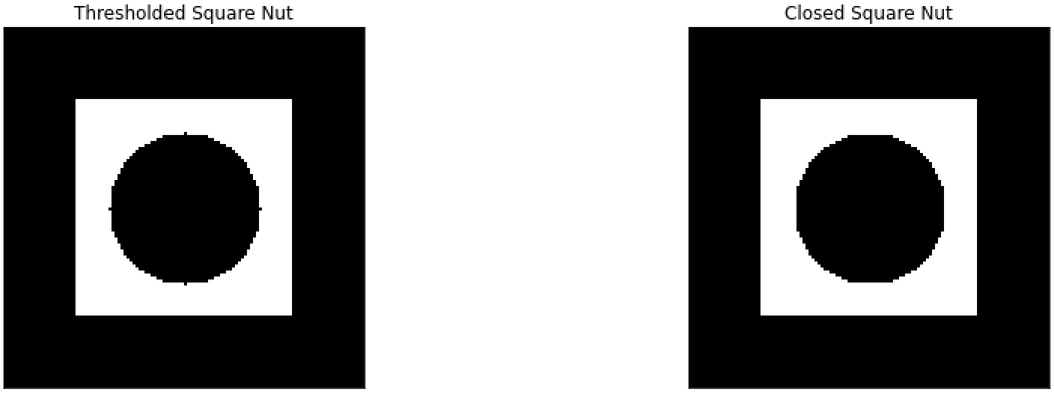
In [3]:

```python
#Your Code Here
kernel = np.ones((3,3),np.uint8)
#The morphology transdormation "Closing" is required to close small holes
close_hex = cv.morphologyEx(thresh_hex, cv.MORPH_CLOSE, kernel)
close_sqr = cv.morphologyEx(thresh_sqr, cv.MORPH_CLOSE, kernel)
close_con_100 = cv.morphologyEx(thresh_con_100, cv.MORPH_CLOSE, kernel)


images = [ thresh_hex, close_hex,
           thresh_sqr, close_sqr,
           thresh_con_100, close_con_100]
titles = [ "Thresholded Hex Nut", "Closed Nex Nut",
           "Thresholded Square Nut", "Closed Square Nut",
           "Thresholded Conveyor 100", "Colsed Conveyor 100"]

for i in range(3):
    plt.figure(figsize=(15,15))
    plt.subplot(3,2,i*2+1), plt.imshow(cv.cvtColor(images[i*2], cv.COLOR_BGR2RGB))
    plt.title(titles[i*2]), plt.xticks([]), plt.yticks([])

    plt.subplot(3,2,i*2+2), plt.imshow(cv.cvtColor(images[i*2+1], cv.COLOR_BGR2RGB))
    plt.title(titles[i*2+1]), plt.xticks([]), plt.yticks([])
```



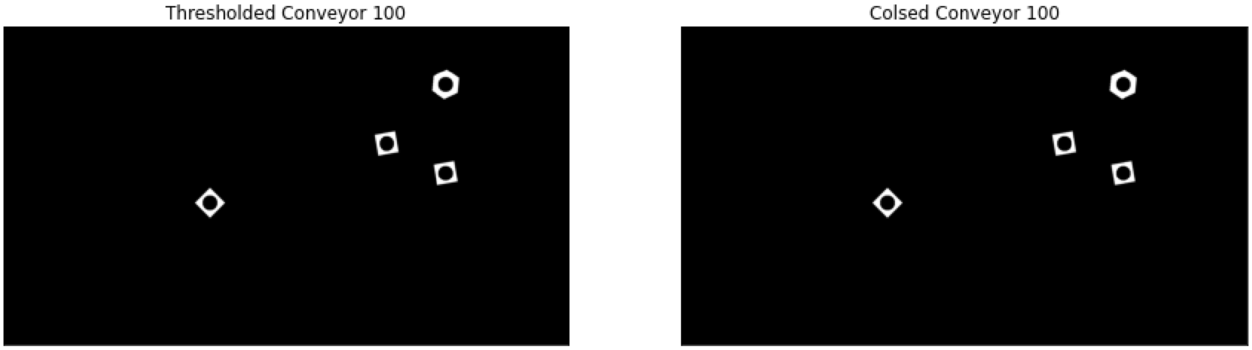
Thresholded Hex Nut

Closed Nex Nut



Thresholded Square Nut

Closed Square Nut



Thresholded Conveyor 100

Colsed Conveyor 100

Question 4

Connected components analysis: apply the `connectedComponentsWithStats` function (see https://docs.opencv.org/4.5.5/d3/dc0/group__imgproc__shape.html#ga107a78bf7cd25dec05fb4dfc5c9e765f (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 [4]:

```
#Your Code Here
connectivity = 4
retval_hex, labels_hex, stats_hex, centroids_hex = cv.connectedComponentsWithStats(close_hex, connectivity, cv
.CV_32S)
retval_sqr, labels_sqr, stats_sqr, centroids_sqr = cv.connectedComponentsWithStats(close_sqr, connectivity, cv
.CV_32S)
retval_con_100, labels_con_100, stats_con_100, centroids_con_100 = cv.connectedComponentsWithStats(close_con_1
00, connectivity, cv.CV_32S)
```

In [17]:

```python
print("Hexnut Template")
print("Number of connected components in the hex nut: ", retval_hex)
for r in range(retval_hex):
    print("\nComponent ",r+1)
    print(stats_hex[r][0],'\t',": Leftmost (x) coordinate")
    print(stats_hex[r][1],'\t',": Topmost (y) coordinate")
    print(stats_hex[r][2],'\t',": Horizontal size of bounding box")
    print(stats_hex[r][3],'\t',": Vertical size of bounding box")
    print(stats_hex[r][4],'\t',": Total area of connected components in pixels")
for r in range(retval_hex):
    print("Centroid of component {}:".format(r+1), centroids_hex[r])

print("\nSquarenut Template")
print("Number of connected component in the square nut: ", retval_sqr)
for r in range(retval_sqr):
    print("\nComponent ",r+1)
    print(stats_sqr[r][0],'\t',": Leftmost (x) coordinate")
    print(stats_sqr[r][1],'\t',": Topmost (y) coordinate")
    print(stats_sqr[r][2],'\t',": Horizontal size of bounding box")
    print(stats_sqr[r][3],'\t',": Vertical size of bounding box")
    print(stats_sqr[r][4],'\t',": Total area of connected components in pixels")
for r in range(retval_sqr):
    print("Centroid of component {}: ".format(r+1), centroids_sqr[r])
print("\nConveyor_f100")
print("Number of connected components in the conveyor 100: ", retval_con_100)
for r in range(retval_con_100):
    print("\nComponent ",r+1)
    print(stats_con_100[r][0],'\t',": Leftmost (x) coordinate")
    print(stats_con_100[r][1],'\t',": Topmost (y) coordinate")
    print(stats_con_100[r][2],'\t',": Horizontal size of bounding box")
    print(stats_con_100[r][3],'\t',": Vertical size of bounding box")
    print(stats_con_100[r][4],'\t',": Total area of connected components in pixels")
print("")
for r in range(retval_con_100):
    print("Centroid of component {}: ".format(r+1), centroids_con_100[r])
```

```
Hexnut Template
Number of connected components in the hex nut:  2

Component  1
0        : Leftmost (x) coordinate
0        : Topmost (y) coordinate
120      : Horizontal size of bounding box
120      : Vertical size of bounding box
9672     : Total area of connected components in pixels

Component  2
10       : Leftmost (x) coordinate
16       : Topmost (y) coordinate
101      : Horizontal size of bounding box
88       : Vertical size of bounding box
4728     : Total area of connected components in pixels
Centroid of component 1: [59.33684864 59.63513234]
Centroid of component 2: [59.83375635 59.22356176]

Squarenut Template
Number of connected component in the square nut:  2

Component  1
0        : Leftmost (x) coordinate
0        : Topmost (y) coordinate
120      : Horizontal size of bounding box
120      : Vertical size of bounding box
11173    : Total area of connected components in pixels

Component  2
24       : Leftmost (x) coordinate
24       : Topmost (y) coordinate
72       : Horizontal size of bounding box
72       : Vertical size of bounding box
3227     : Total area of connected components in pixels
Centroid of component 1:  [59.5875772 59.5875772]
Centroid of component 2:  [59.19677719 59.19677719]

Conveyor_f100
Number of connected components in the conveyor 100:  5

Component  1
0        : Leftmost (x) coordinate
0        : Topmost (y) coordinate
1920     : Horizontal size of bounding box
1080     : Vertical size of bounding box
2059646          : Total area of connected components in pixels

Component  2
1454     : Leftmost (x) coordinate
150      : Topmost (y) coordinate
92       : Horizontal size of bounding box
100      : Vertical size of bounding box
4636     : Total area of connected components in pixels

Component  3
1259     : Leftmost (x) coordinate
359      : Topmost (y) coordinate
82       : Horizontal size of bounding box
82       : Vertical size of bounding box
3087     : Total area of connected components in pixels

Component  4
1459     : Leftmost (x) coordinate
459      : Topmost (y) coordinate
82       : Horizontal size of bounding box
82       : Vertical size of bounding box
3087     : Total area of connected components in pixels

Component  5
650      : Leftmost (x) coordinate
550      : Topmost (y) coordinate
101      : Horizontal size of bounding box
101      : Vertical size of bounding box
3144     : Total area of connected components in pixels
```

```
Centroid of component 1:  [957.36323524 540.44416273]
Centroid of component 2:  [1499.24201898  199.28515962]
Centroid of component 3:  [1299.18302559  399.18302559]
Centroid of component 4:  [1499.18302559  499.18302559]
Centroid of component 5:  [700. 600.]
```

Question 5

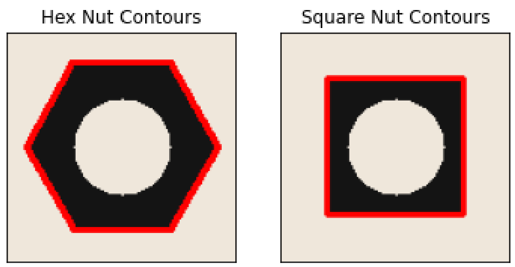
Contour analysis: Use `findContours` function to retrieve the *extreme outer* contours. (see https://docs.opencv.org/4.5.2/d4/d73/tutorial_py_contours_begin.html (https://docs.opencv.org/4.5.2/d4/d73/tutorial_py_contours_begin.html) for help and https://docs.opencv.org/4.5.2/d3/dc0/group__imgproc__shape.html#gadf1ad6a0b82947fa1fe3c3d497f260e0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

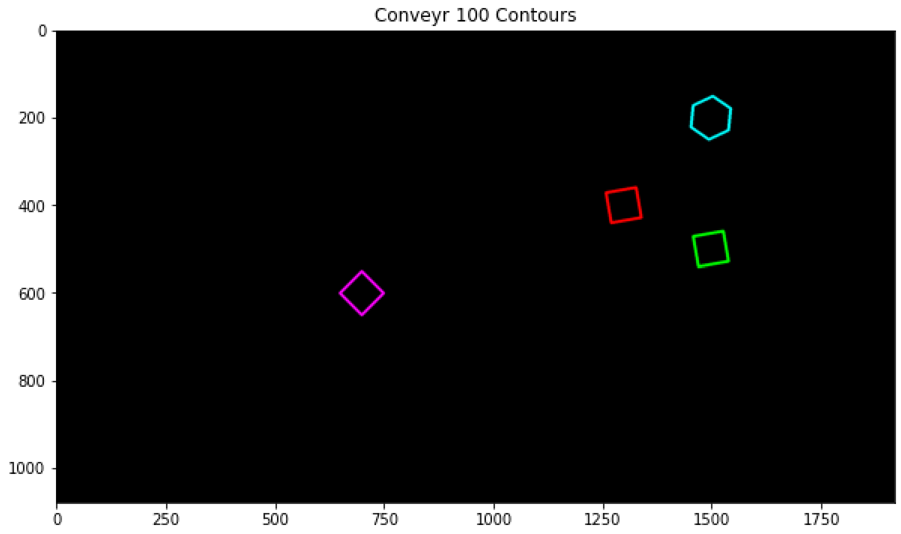
Display these contours. You should see something like the following:

Extreme Outer Contours

In [20]:

```
#Your Code Here
hex_contours, hierarchy_hex     =       cv.findContours(close_hex, cv.RETR_TREE, cv.CHAIN_APPROX_SIMPLE)
sqr_contours, hierarchy_sqr     =       cv.findContours(close_sqr, cv.RETR_TREE, cv.CHAIN_APPROX_SIMPLE)

hex_cont_img = hexnut_template.copy()
sqr_cont_img = squarenut_template.copy()

cv.drawContours(hex_cont_img, hex_contours, 0, (0,0,255), 2)
cv.drawContours(sqr_cont_img, sqr_contours, 0, (0,0,255), 2)

images = ( hex_cont_img, sqr_cont_img )
titles = ("Hex Nut Contours", "Square Nut Contours")

for i in range(2):
    plt.subplot(1,2,i+1), plt.imshow(cv.cvtColor(images[i], cv.COLOR_BGR2RGB))
    plt.title(titles[i]), plt.xticks([]), plt.yticks([])
plt.show()

plt.figure(figsize=(10,10))
plt.title("Conveyr 100 Contours")

con_100_contours, hierarchy = cv.findContours(close_con_100, cv.RETR_EXTERNAL, cv.CHAIN_APPROX_SIMPLE)
con_copy=cv.cvtColor(close_con_100.copy(),cv.COLOR_BGR2RGB)

black_bg=np.zeros(conveyor_f100.shape,dtype=int)
colors=[(255,0,255),(0,255,0),(255,0,0),(0,255,255)]
for i in range(len(con_100_contours)):
    cv.drawContours(black_bg,con_100_contours,i,colors[i],5)
plt.imshow(black_bg)
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.

Open the sequence and play it using the code below.

In [21]:
```
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.
```

Question 6

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 (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.

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 [24]:
```
total_matches = 0
for i in range(len(con_100_contours)):
    ret = cv.matchShapes(con_100_contours[0], con_100_contours[i], 1, 0.0)
    if ret==0.0:
        total_matches+=1
print("Number of Hexagonal Nuts: ",total_matches)
```

```
Number of Hexagonal Nuts:  1
```

In [25]:
```
def Hex_Count(hex_con, vid_frame):
    global hexnut_count
    global ref

    vid_frame_gray = cv.cvtColor(vid_frame, cv.COLOR_BGR2GRAY)
    ret_vid_frame, thresh_vid_frame = cv.threshold(vid_frame_gray, 0,255,cv.THRESH_BINARY+cv.THRESH_OTSU)

    thresh_vid_frame = cv.bitwise_not(thresh_vid_frame)

    close_vid_frame = cv.morphologyEx(thresh_vid_frame, cv.MORPH_CLOSE, np.ones((3,3)))
    vid_frame_contours, hierarchy_vid_frame = cv.findContours(close_vid_frame, cv.RETR_EXTERNAL, cv.CHAIN_APPR
OX_SIMPLE)

    hex_count= 0
    ref_ = 0
    for i in vid_frame_contours:
        cen_hex = min(i[:,0,0])
        ret_vid_frame = cv.matchShapes(hex_con[0], i, 1, 0.0)
        if ret_vid_frame < 0.002:
            hex_count+=1
            if ref_ < cen_hex:
                ref_ = cen_hex
            if cen_hex > ref:
                hexnut_count += 1

    if any([hex_count]):
        ref = ref_
    return hex_count
```

In [26]:

```
frames = []
shape = (1080, 1920, 3)

hexnut_count, ref = 0, 0

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

    hex_c = Hex_Count(hex_contours, frame)
    f_num += 1

    text1 = "Frame: " + str(f_num)
    text2 = "Hexagonal Nuts in the current frame = " + str(hex_c)
    text3 = "Total Hexagonal Nuts = " + str(hexnut_count)

    cv.putText(frame, text1, (50, 50), cv.FONT_HERSHEY_COMPLEX, 1, (0,255,0), 1, cv.LINE_AA)
    cv.putText(frame, text2, (50, 100), cv.FONT_HERSHEY_COMPLEX, 1, (255,0,0), 1, cv.LINE_AA)
    cv.putText(frame, text3, (50, 150), cv.FONT_HERSHEY_COMPLEX, 1, (0,0,255), 1, cv.LINE_AA)
    cv.imshow('Conveyor', frame)
    frames.append(frame)

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

cap.release()
out = cv.VideoWriter('conveyor_result_190009U.mp4',cv.VideoWriter_fourcc(*'h264'), 30, (shape[1], shape[0]))
cv.destroyAllWindows()

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

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

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

Github Link

https://github.com/akilaabeyratne/EN2550-Assignment-3 (https://github.com/akilaabeyratne/EN2550-Assignment-3)