Assignment 3

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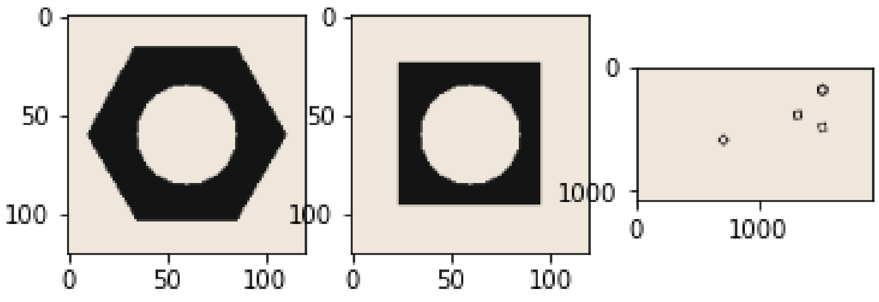
Connected Component Analysis

In [ ]:

```
import cv2 as cv
import numpy as np
import matplotlib.pyplot as plt
import random as rng
import math
```

In [ ]:

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

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

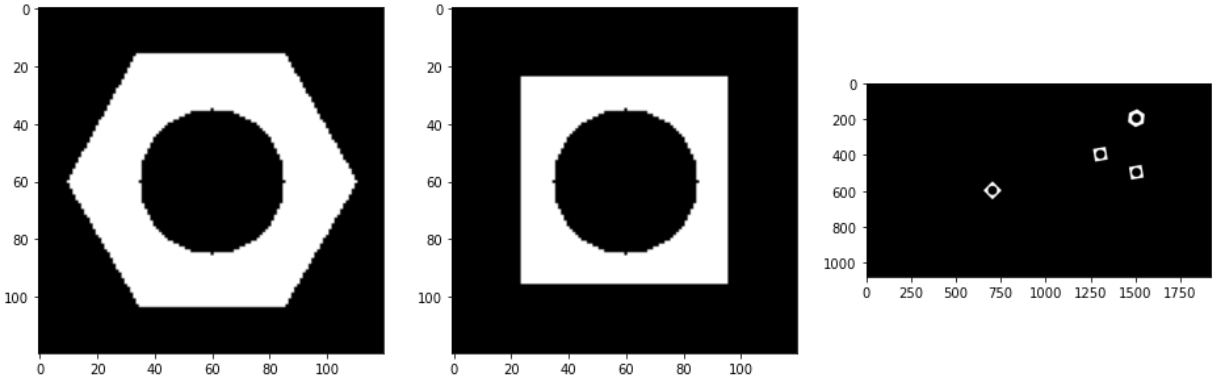


Converting to Gray scale and applying Otsu's thresholding

In [ ]:

```
#Convert to gray scale
hexnut_gray = cv.cvtColor(hexnut_template, cv.COLOR_RGB2GRAY)
squarenut_gray = cv.cvtColor(squarenut_template, cv.COLOR_RGB2GRAY)
conveyor_f100_gray = cv.cvtColor(conveyor_f100, cv.COLOR_RGB2GRAY)

#Apply otsu thresholding
ret_hexnut,th_hexnut = cv.threshold(hexnut_gray,0,255,cv.THRESH_BINARY
ret_squarenut,th_squarenut = cv.threshold(squarenut_gray,0,255,cv.THRE
ret_f100,th_f100 = cv.threshold(conveyor_f100_gray,0,255,cv.THRESH_BIN

print("Threshold for hexnut:",ret_hexnut)
print("Threshold for squarenut:",ret_squarenut)
print("Threshold for conveyor belt image :",ret_f100)

fig, ax = plt. subplots(1,3, figsize=(16,10))
ax[0].imshow(cv.cvtColor(th_hexnut, cv.COLOR_RGB2BGR))
ax[1].imshow(cv.cvtColor(th_squarenut, cv.COLOR_RGB2BGR))
ax[2].imshow(cv.cvtColor(th_f100, cv.COLOR_RGB2BGR))
plt.show()
```

```
Threshold for hexnut: 20.0
Threshold for squarenut: 20.0
Threshold for conveyor belt image : 20.0
```



Morphological Closing

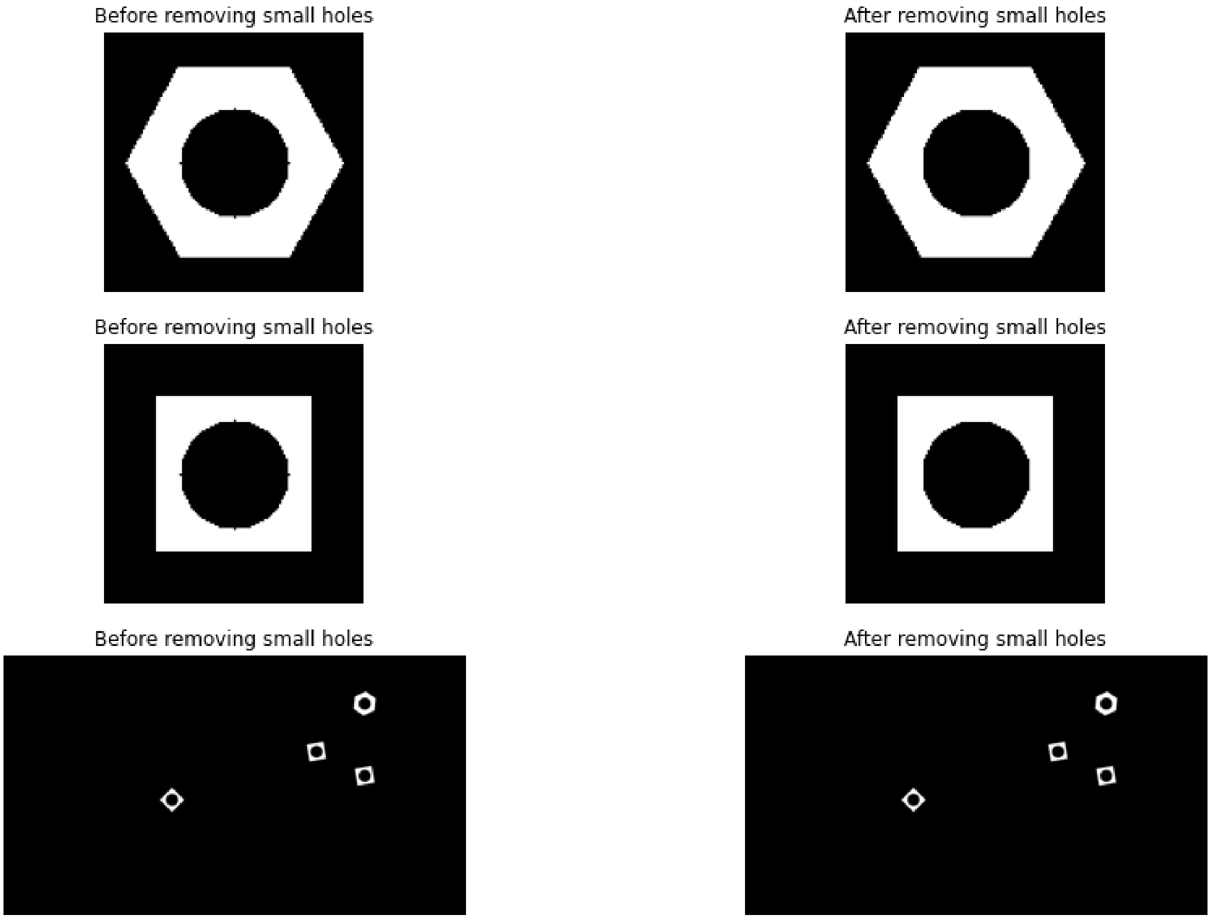
In [ ]:

```
kernel= cv.getStructuringElement(cv.MORPH_RECT,(3,3))

#Apply morphological closing
hexnut_closing = cv.morphologyEx(th_hexnut, cv.MORPH_CLOSE, kernel)
squarenut_closing = cv.morphologyEx(th_squarenut, cv.MORPH_CLOSE, kerr
f100_closing = cv.morphologyEx(th_f100, cv.MORPH_CLOSE, kernel)

fig, ax = plt. subplots(3,2,figsize = (15,10))

ax[0][0].imshow(cv.cvtColor(th_hexnut, cv.COLOR_RGB2BGR))
ax[0][0].set_title("Before removing small holes")
ax[0][0].axis("off")
ax[0][1].imshow(cv.cvtColor(hexnut_closing, cv.COLOR_RGB2BGR))
ax[0][1].set_title("After removing small holes")
ax[0][1].axis("off")

ax[1][0].imshow(cv.cvtColor(th_squarenut, cv.COLOR_RGB2BGR))
ax[1][0].set_title("Before removing small holes")
ax[1][0].axis("off")
ax[1][1].imshow(cv.cvtColor(squarenut_closing, cv.COLOR_RGB2BGR))
ax[1][1].set_title("After removing small holes")
ax[1][1].axis("off")

ax[2][0].imshow(cv.cvtColor(th_f100, cv.COLOR_RGB2BGR))
```

```
ax[2][0].set_title("Before removing small holes")
ax[2][0].axis("off")
ax[2][1].imshow(cv.cvtColor(f100_closing, cv.COLOR_RGB2BGR))
ax[2][1].set_title("After removing small holes")
ax[2][1].axis("off")
```

Out[ ]:

```
(-0.5, 1919.5, 1079.5, -0.5)
```


Before removing small holes
After removing small holes
Before removing small holes
After removing small holes
Before removing small holes
After removing small holes

Finding the connected components with stats

In [ ]:

```
connectivity = 8

f100_output = cv.connectedComponentsWithStats(f100_closing, connectivi
hex_output = cv.connectedComponentsWithStats(hexnut_closing, connectiv
square_output = cv.connectedComponentsWithStats(squarenut_closing, cor

f100_labels = f100_output[0]
f100_stats = f100_output[2]
f100_centroids = f100_output[3]

hex_labels = hex_output[0]
hex_stats = hex_output[2]
hex_centroids = hex_output[3]
```

```
square_labels = square_output[0]
square_stats = square_output[2]
square_centroids = square_output[3]

print("Number of connected Components: ",f100_labels )
print("Statistics of Conveyor Belt:\n",f100_stats)
print("Statistics of square nuts:\n",square_stats)
print("Statistics of hexagonal nuts:\n",hex_stats)

print("centroids:\n", f100_centroids)
```

```
Number of connected Components:  5
Statistics of Conveyor Belt:
 [[      0       0    1920    1080 2059646]
 [   1454     150      92     100    4636]
 [   1259     359      82      82    3087]
 [   1459     459      82      82    3087]
 [    650     550     101     101    3144]]
Statistics of square nuts:
 [[    0     0   120   120 11173]
 [   24    24    72    72  3227]]
Statistics of hexagonal nuts:
 [[   0    0  120  120 9672]
 [  10   16  101   88 4728]]
centroids:
 [[ 957.36323524  540.44416273]
 [1499.24201898  199.28515962]
 [1299.18302559  399.18302559]
 [1499.18302559  499.18302559]
 [ 700.          600.        ]]
```

b. What are the statistics?

Each row contains the statistics of each connected component. The first row always corresponds to the background.

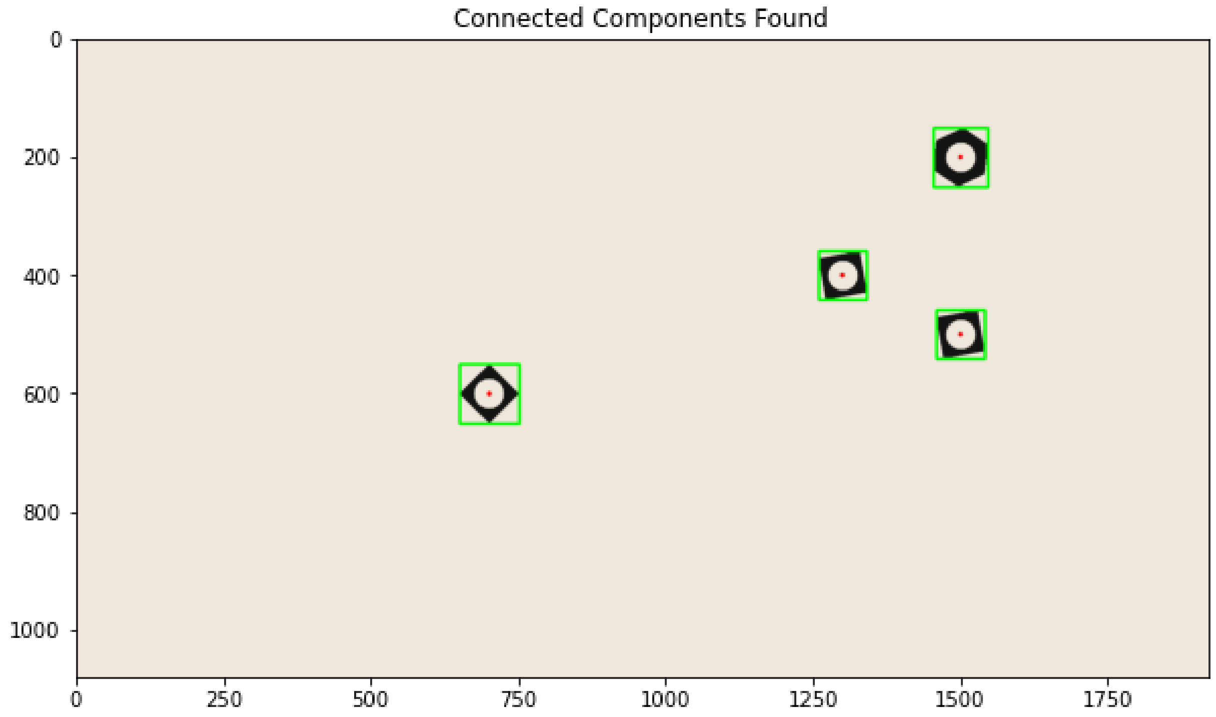
1. column 1: The leftmost x coordinate of the bounding box.
2. column 2: The topmost y coordinate of the bounding box.
3. column 3: The width of the bounding box.
4. column 4: The height of the bounding box.
5. column 5: The total area (in pixels) of the connected component.

In [ ]:

```
#Display the connected components
output = conveyor_f100.copy()

#ignore the first component which is the background
for i in range(1, f100_labels):
        x = f100_stats[i, cv.CC_STAT_LEFT]
        y = f100_stats[i, cv.CC_STAT_TOP]
        w = f100_stats[i, cv.CC_STAT_WIDTH]
        h = f100_stats[i, cv.CC_STAT_HEIGHT]
        area = f100_stats[i, cv.CC_STAT_AREA]
        (cX, cY) = f100_centroids[i]
        cv.rectangle(output, (x, y), (x + w, y + h), (0, 255, 0), 3)
        cv.circle(output, (int(cX), int(cY)), 4, (0, 0, 255), -1)
plt.figure(figsize=(10,10))
plt.title("Connected Components Found")
plt.imshow(cv.cvtColor(output, cv.COLOR_RGB2BGR))
```

Out[ ]:

```
<matplotlib.image.AxesImage at 0x1b580c09730>
```



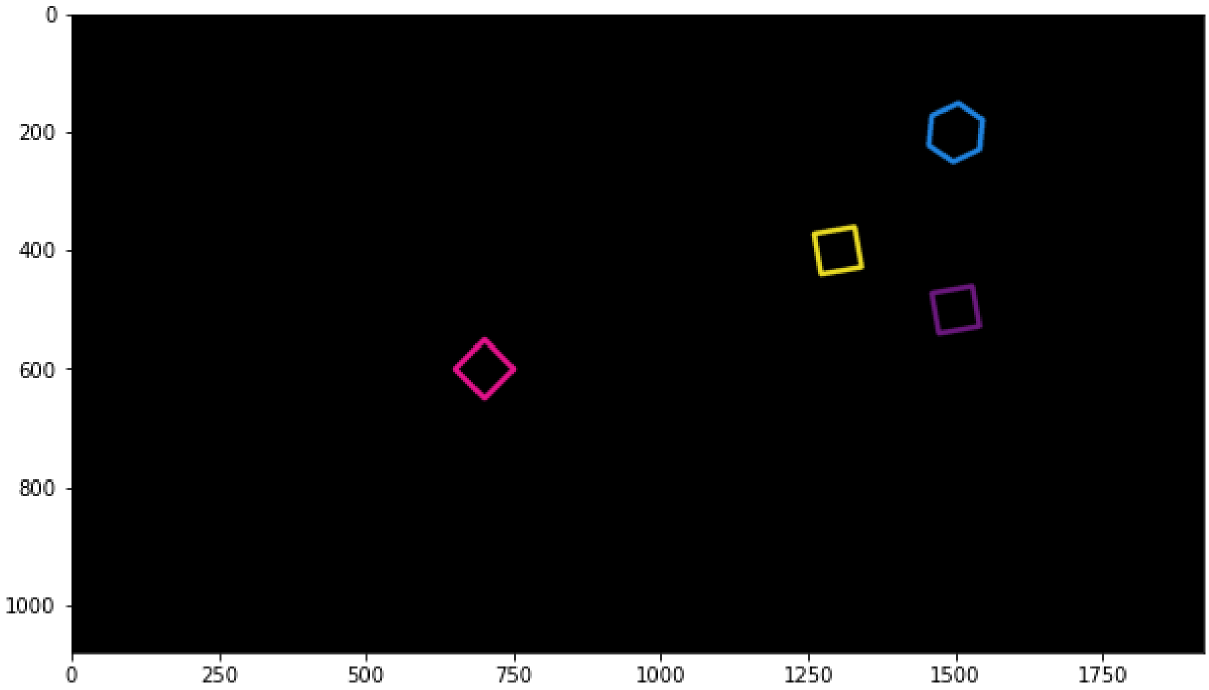
Drawing the Extreme Outer contours

In [ ]:

```
drawing = np.zeros((f100_closing.shape[0], f100_closing.shape[1], 3),
contours, hierarchy = cv.findContours(f100_closing, cv.RETR_EXTERNAL,
for i in range(len(contours)):
    color = (rng.randint(0,256), rng.randint(0,256), rng.randint(0,256
    cv.drawContours(drawing, contours, i, color, 7, cv.LINE_8, hierarc

plt.figure(figsize=(10,10))
plt.imshow(drawing)
```

Out[ ]:

```
<matplotlib.image.AxesImage at 0x1b582979df0>
```



Detecting Objects on a Synthetic Conveyor

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
    cv.imshow('Conveyor', frame)

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

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

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

In [ ]:

```
hex_contours, hex_hierarchy = cv.findContours(hexnut_closing, cv.RETR_
hex_cnt = hex_contours[0]

square_contours, square_hierarchy = cv.findContours(squarenut_closing,
square_cnt = square_contours[0]

count = 0

for i in range (0,len(contours)):
    cnti = contours[i]
    reti = cv.matchShapes(hex_cnt,cnti,1,0.0)
    if reti<0.005:
        count+=1
print("Number of Hexagonal nuts: ",count)
```

```
Number of Hexagonal nuts:  1
```

In [ ]:

```
#function for processing frames
def process(frame,kernel):
    frame_gray = cv.cvtColor(frame, cv.COLOR_RGB2GRAY)
    ret,th = cv.threshold(frame_gray,0,255,cv.THRESH_BINARY_INV+cv.THR
    frame_closing = cv.morphologyEx(th, cv.MORPH_CLOSE, kernel)
    return frame_closing
```

In [ ]:

```
# Writing the video
frame_array = []
shape = (1080, 1920, 3)

cap = cv.VideoCapture('conveyor.mp4')
prev_frame = []
tracking = {}
id = 0
frame_count = 0
while cap.isOpened():
    ret, frame = cap.read()
    frame_count+=1
    if not ret:
        print("Can't receive frame (stream end?). Exiting.")
        break

    count = 0
    processed_frame = process(frame,kernel)
    current_frame = []
    fcontours, fhierarchy = cv.findContours(processed_frame, cv.RETR_E

    #Find the contours in the frame
    for i in range (0,len(fcontours)):
        cnti = fcontours[i]
        area = cv.contourArea(cnti)
        hex_ret = cv.matchShapes(hex_cnt,cnti,1,0.0)
        square_ret = cv.matchShapes(square_cnt,cnti,1,0.0)
        #Check if a hexagonal nut is found
        if hex_ret<0.0005 and area>6400:
            moment = cv.moments(fcontours[i])
            cx, cy = int(moment['m10']/moment['m00']),int(moment['m01'
            current_frame.append((cx, cy))
            count+=1

        #Check if a square nut is found
        elif square_ret<0.0005 and area>4900:
            moment = cv.moments(fcontours[i])
            cx, cy = int(moment['m10']/moment['m00']),int(moment['m01'
            current_frame.append((cx, cy))
            count+=1

   # compare previous and current frame in the first two frames
    if frame_count <= 2:
        for pt in current_frame:
            for pt2 in prev_frame:
                distance = math.hypot(pt2[0] - pt[0], pt2[1] - pt[1])
                #find the distance between centroids
                if distance < 100:
                    tracking[id] = pt
                    id += 1
    else:
        tracking_copy = tracking.copy()
        current_frame_copy = current_frame.copy()
        for object_id, pt2 in tracking_copy.items():
            object_found = False
            for pt in current_frame_copy:
                #find the distance between centroids
                distance = math.hypot(pt2[0] - pt[0], pt2[1] - pt[1])
                # Update IDs points if it was found in the tracked obj
                if distance < 100:
                    tracking[object_id] = pt
                    object_found = True
                    if pt in current_frame:
                        current_frame.remove(pt)
                    continue
            # Remove IDs which are not in the current frame
            if not object_found:
                tracking.pop(object_id)
        # Add new IDs found in the current frame
        for pt in current_frame:
            tracking[id] = pt
            id += 1

    prev_frame = current_frame.copy()
    text = 'Frame:' + str(frame_count) +" Objects in Frame:  "+str(cou
    cv.putText(frame,text , (100, 100), cv.FONT_HERSHEY_COMPLEX, 1, (0
    frame_array.append(frame)
    if cv.waitKey(1) == ord('q'):
        break


out = cv.VideoWriter('./conveyor_result_190713X.mp4',cv.VideoWriter_fc

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])

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

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