

Assignment 05

July 6, 2021

1 EN2550 Image Processing and Machine Vision - 2021

1.1 Assignment 05: Object Counting on a Conveyor Belt

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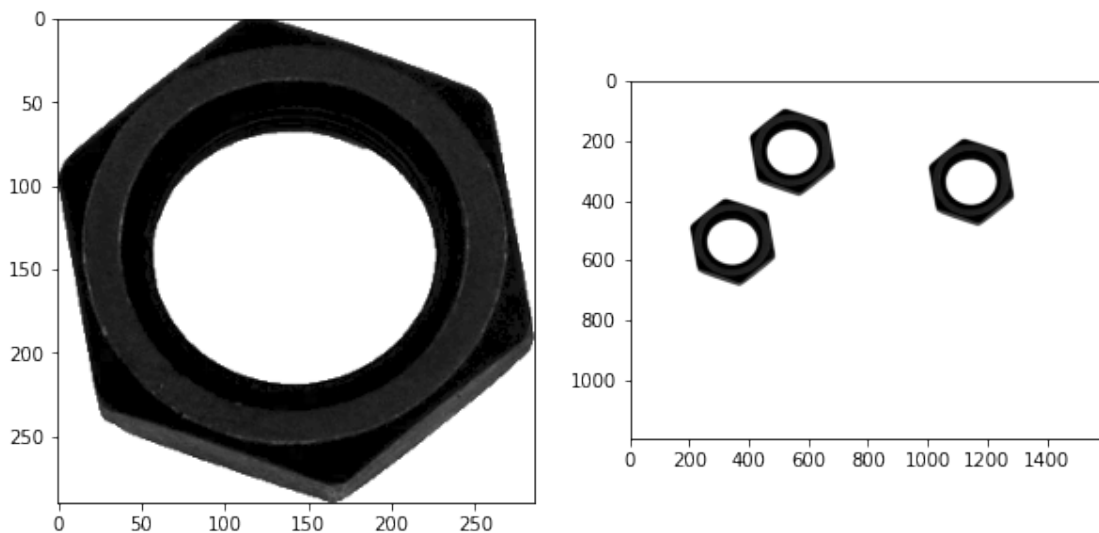
Code available at <https://git.io/JcPQd>

```
[226]: import cv2 as cv
import numpy as np
import matplotlib.pyplot as plt
from google.colab.patches import cv2_imshow

%matplotlib inline
```

```
[227]: template_im = cv.imread(r'template.png', cv.IMREAD_GRAYSCALE)
belt_im = cv.imread(r'belt.png', cv.IMREAD_GRAYSCALE)

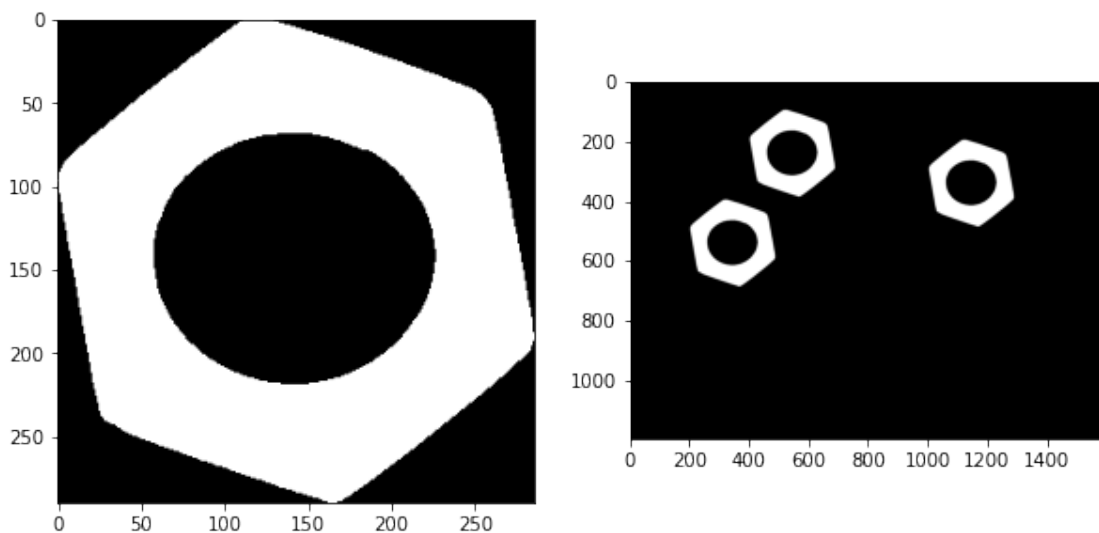
fig, ax = plt.subplots(1, 2, figsize=(10,10))
ax[0].imshow(template_im, cmap='gray')
ax[1].imshow(belt_im, cmap='gray')
plt.show()
```



2 PART I

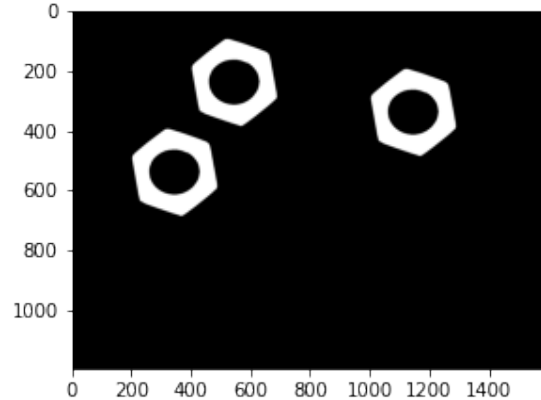
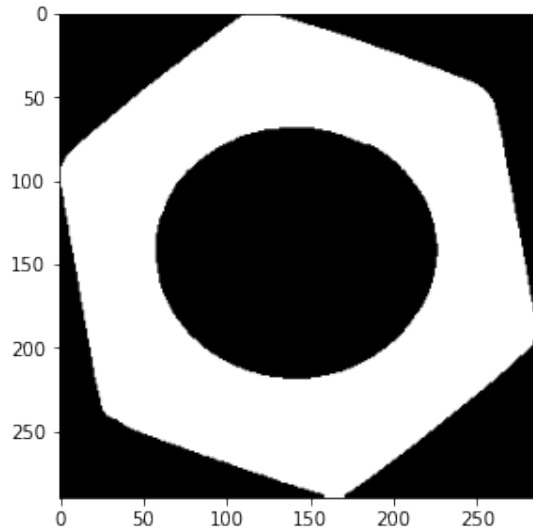
```
[228]: th_t, img_t = cv.threshold(template_im, 0, 255, cv.THRESH_BINARY_INV + cv.  
      ↪THRESH_OTSU)  
th_b, img_b = cv.threshold(belt_im, 0, 255, cv.THRESH_BINARY_INV + cv.  
      ↪THRESH_OTSU)
```

```
[229]: fig, ax = plt.subplots(1, 2, figsize=(10,10))  
ax[0].imshow(img_t, cmap='gray')  
ax[1].imshow(img_b, cmap='gray')  
plt.show()
```



```
[230]: kernel = np.ones((3,3), dtype=np.uint8)  
closing_t = cv.morphologyEx(img_t, cv.MORPH_CLOSE, kernel)  
closing_b = cv.morphologyEx(img_b, cv.MORPH_CLOSE, kernel)
```

```
[231]: fig, ax = plt.subplots(1, 2, figsize=(10,10))  
ax[0].imshow(closing_t, cmap='gray')  
ax[1].imshow(closing_b, cmap='gray')  
plt.show()
```



```
[232]: retval_t, labels_t, stats_t, centroids_t = cv.
        ↳connectedComponentsWithStats(closing_t)
        retval_b, labels_b, stats_b, centroids_b = cv.
        ↳connectedComponentsWithStats(closing_b)
```

```
[233]: print("Number of connected components on template:", np.unique(labels_t).
        ↳shape[0], "\nNumber of connected components on belt:", np.unique(labels_b).
        ↳shape[0], end='\n\n')
        print("Stats for template:\n", stats_t, "\nStats for belt:\n", stats_b,
        ↳end='\n\n')
        print("Centeroids of template:\n", centroids_t, "\nCenteroids on belt:\n",
        ↳centroids_b, end='\n\n')
```

Number of connected components on template: 2

Number of connected components on belt: 4

Stats for template:

```
[[ 0  0 286 290 42290]
 [ 0  0 286 290 40650]]
```

Stats for belt:

```
[[ 0  0 1600 1200 1798161]
 [ 400 100 286 290 40613]
 [ 1000 200 286 290 40613]
 [ 200 400 286 290 40613]]
```

Centeroids of template:

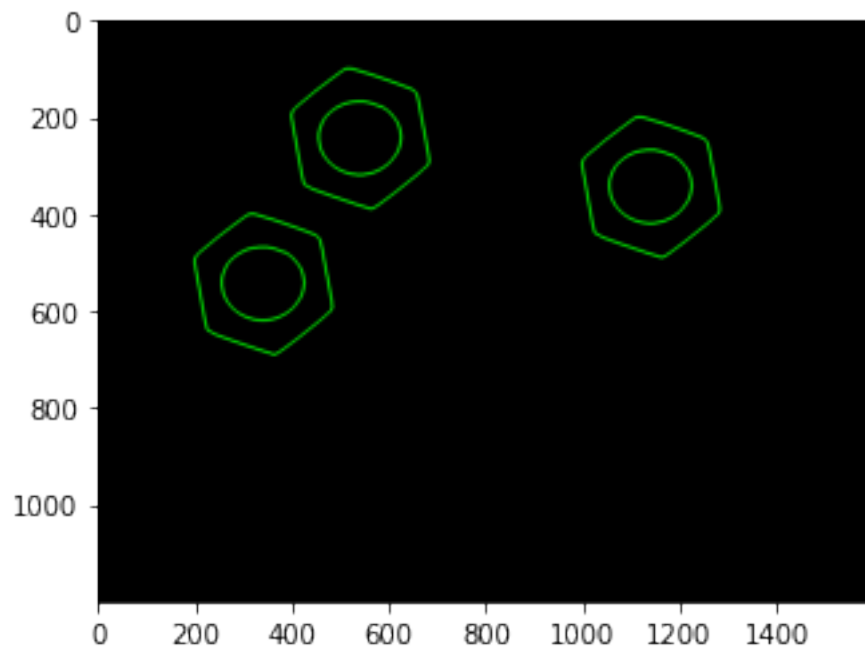
```
[[142.18770395 145.19172381]
 [142.82489545 143.780369  ]]
```

Centeroids on belt:

```
[[ 807.85728475  614.56805258]
 [ 542.82567158  243.78479797]
 [1142.82567158  343.78479797]
 [ 342.82567158  543.78479797]]
```

```
[234]: contours_t, hierarchy_t = cv.findContours(closing_t, cv.RETR_TREE, cv.
        ↪CHAIN_APPROX_SIMPLE)
contours_b, hierarchy_b = cv.findContours(closing_b, cv.RETR_TREE, cv.
        ↪CHAIN_APPROX_SIMPLE)
```

```
[235]: # Visualizing contours
im_contours_belt = np.zeros((belt_im.shape[0],belt_im.shape[1],3), np.uint8)
conts = cv.drawContours(im_contours_belt, contours_b, -1, (0,255,0), 3).
        ↪astype('uint8')
plt.imshow(conts)
plt.show()
```



```
[236]: label = 1 # remember that the label of the background is 0
belt = ((labels_b >= label)*255).astype('uint8')
belt_cont, template_hierarchy = cv.findContours(belt, cv.RETR_EXTERNAL, cv.
        ↪CHAIN_APPROX_SIMPLE)
for j,c in enumerate(belt_cont):
    print(cv.matchShapes(contours_t[0], c, cv.CONTOURS_MATCH_I1, 0.0))
```

```
0.00010071698397151607
```

```
0.00010071698397928763
0.00010071698397484674
```

3 PART II

```
[237]: ca = cv.contourArea(contours_b[1])
       print(ca)
```

```
20080.0
```

```
[238]: M = cv.moments(contours_b[1])
       cx, cy = int(M['m10']/M['m00']), int(M['m01']/M['m00'])
       print(cx, cy)
```

```
341 542
```

```
[239]: count = 1
       object_prev_frame = np.array([cx, cy, ca, count])
```

```
[240]: delta_x = 15
```

4 PART III - GRADING

4.1 get_indexed_image function

```
[241]: def get_indexed_image(im):
       """
       Thresholding, closing, and connected component anysis lumped
       """
       th, img = cv.threshold(im, 0, 255, cv.THRESH_BINARY_INV + cv.THRESH_OTSU)
       kernel = np.ones((3,3), dtype=np.uint8)
       closing = cv.morphologyEx(img, cv.MORPH_CLOSE, kernel)
       retval, labels, stats, centroids = cv.connectedComponentsWithStats(closing)
       return retval, labels, stats, centroids
```

4.2 is_new function

```
[242]: def is_new(a, b, delta, i):
       """
       Vector Dissimilarity with an Array of Vectors
       Checks if vector b is similar to a one or more vectors in a outside the
       →tolerances specified in delta.
       vector i specified which elements in b to compare with those in a
       """
       if (np.absolute(a[:,i] - b[i]) > delta).all(): return True
       return False
```

```
[243]: # check is_new expected answer False

a = np.array([[1.36100e+03, 5.53000e+02, 5.99245e+04, 2.00000e+00],
              [7.61000e+02, 4.53000e+02, 5.99385e+04, 1.00000e+00],
              [1.55200e+03, 2.43000e+02, 6.00585e+04, 3.00000e+00]])
b = np.array([7.51000e+02, 4.53000e+02, 5.99385e+04, 3.00000e+00])
delta = np.array([delta_x])
i = np.array([0])

assert is_new(a, b, delta, i) == False, " Check the function "
```

4.3 prev_index function

```
[244]: def prev_index(a, b, delta, i):
        """
        Returns Previous Index
        Returns the index of the appearance of the object in the previous frame
        """
        index = np.where(np.absolute(a[:,i] - b[i]) <= delta)
        return index[0]
```

```
[245]: # check prev_index expected answer 1

a = np.array([[1.36100e+03, 5.53000e+02, 5.99245e+04, 2.00000e+00],
              [7.61000e+02, 4.53000e+02, 5.99385e+04, 1.00000e+00],
              [1.55200e+03, 2.43000e+02, 6.00585e+04, 3.00000e+00]])
b = np.array([7.51000e+02, 4.53000e+02, 5.99385e+04, 3.00000e+00])
delta = np.array([delta_x])
i = np.array([0])

assert prev_index(a,b,delta,i) == 1, " Check the function "
```

5 Using above functions to detect objects in videos

6 Detect hexagonal nuts in conveyor_two_frame.mp4

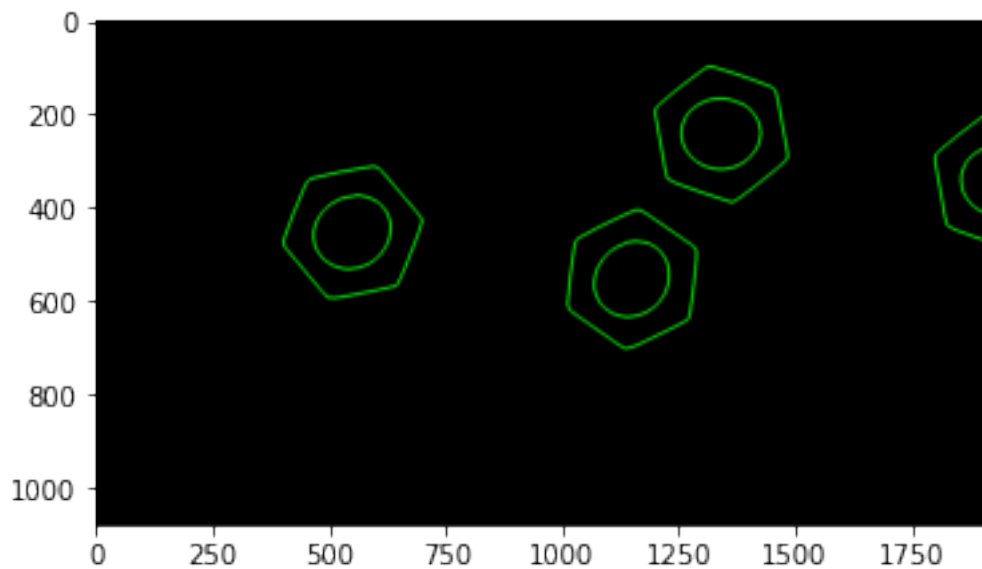
```
[260]: col_frames = []
frames = []
cap = cv.VideoCapture('conveyor_two_frame.mp4') # give the correct path here
while cap.isOpened():
    ret, frame = cap.read()
    if not ret:
        print("Can't receive frame (stream end?). Exiting ...")
        break
    col_frames.append(frame)
    frames.append(cv.cvtColor(frame, cv.COLOR_BGR2GRAY))
cap.release()
```

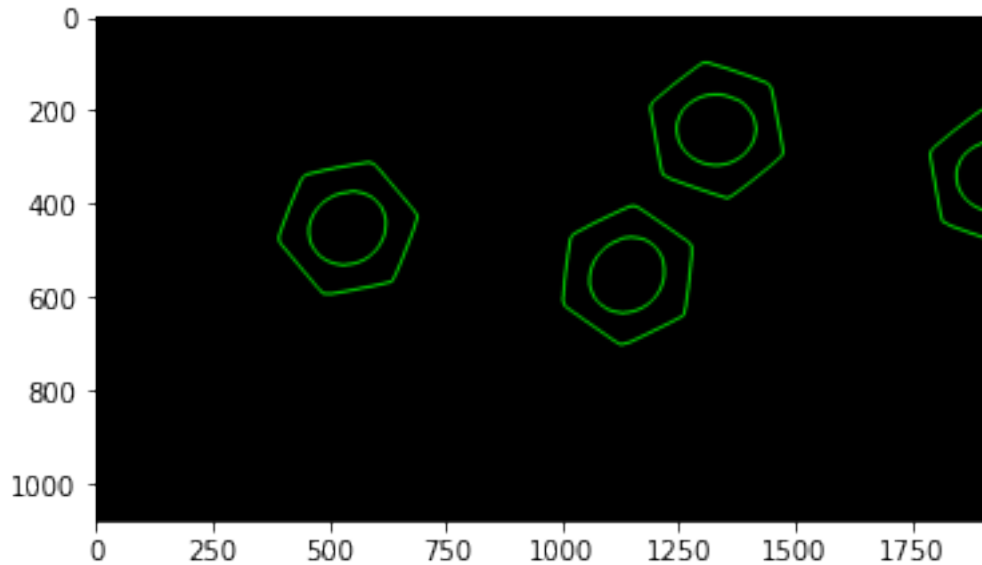
```
cv.destroyAllWindows()
frames = np.array(frames)
print("Frames shape:", frames.shape)
```

Can't receive frame (stream end?). Exiting ...
Frames shape: (2, 1080, 1920)

6.1 Drawing contours in each frame

```
[261]: for grey in frames:
        retval, labels, stats, centroids = get_indexed_image(grey)
        contours, hierarchy = cv.findContours(((labels >= 1)*255).astype('uint8'), cv.
        ↳RETR_TREE, cv.CHAIN_APPROX_SIMPLE)
        im_contours_belt = np.zeros((grey.shape[0],grey.shape[1],3), np.uint8)
        conts = cv.drawContours(im_contours_belt, contours, -1, (0,255,0), 3).
        ↳astype('uint8')
        plt.imshow(conts)
        plt.show()
```





6.2 Segmentation

Going through the video frame-by-frame, generating the object flow of each frame by detecting contours, comparing their shapes with template, comparing the area of the contours, and saving the hexagonal objects in each frame.

```
[267]: object_flow = []
matching_threshold = 4.5e-3
for grey in frames:
    retval, labels, stats, centroids = get_indexed_image(grey)
    contours, hierarchy = cv.findContours(((labels >= 1)*255).astype('uint8'), cv.
    ↳RETR_TREE, cv.CHAIN_APPROX_SIMPLE)
    frame_objects = []
    for i in range(len(contours)):
        if cv.matchShapes(contours_t[0], contours[i], cv.CONTOURS_MATCH_I1, 0.0) >↳
        ↳matching_threshold: continue
        ca = int(cv.contourArea(contours[i]))
        if ca<59500: continue
        M = cv.moments(contours[i])
        cx, cy = int(M['m10']/M['m00']), int(M['m01']/M['m00'])
        frame_objects.append([cx, cy, ca, i+1])
    frame_objects = np.array(frame_objects)
    object_flow.append(frame_objects)
```

6.3 Counting

Checking for new objects and counting the number of unique nuts. However, this is not effective for this short video as it has no rotation of objects.


```
[268]: prev_frame = object_flow[0]
obj_count = object_flow[0].shape[0]
for frame in object_flow[1:]:
    for obj in frame:
        if is_new(prev_frame, obj, 15, 0):
            obj_count+=1
    prev_frame = frame
print("Detected", obj_count, "nuts in the video")
```

Detected 3 nuts in the video

6.4 Tracking

By going through the object flow frame-by-frame; identifying new objects in each frame, giving identification numberd to new objects and assigning the same identification number to objects coming from previous frame.

```
[269]: prev_frame = object_flow[0]
obj_count = object_flow[0].shape[0]
for frame in object_flow[1:]:
    for obj in frame:
        if is_new(prev_frame, obj, delta_x, 0):
            obj_count+=1
            obj[3] = obj_count
        else:
            obj[3] = prev_frame[prev_index(prev_frame, obj, delta_x, 0)][0, 3]
    prev_frame = frame
```

6.5 Adding text

Embed the identification number of each object in each frame. Here, the original color image is used.

```
[270]: for i in range(len(frames)):
    frame = col_frames[i]
    for obj in object_flow[i]:
        frame = cv.putText(frame, str(int(obj[3])), (int(obj[0]), int(obj[1])), cv.
        FONT_HERSHEY_SIMPLEX, 2, (0,0,255), 2)
```

6.6 Encoding

Using MP4V encoder

```
[271]: # Encoding the frames
file_name = 'test1.mp4'
fourcc = cv.VideoWriter_fourcc(*'MP4V')
out = cv.VideoWriter(file_name, fourcc, 30.0, (1920, 1080), True)
for frame in col_frames:
    out.write(frame)
```

```
# Release everything if job is finished
out.release()
```

7 Detect hexagonal nuts in conveyor_with_rotation.mp4

```
[252]: col_frames = []
frames = []
cap = cv.VideoCapture('/content/drive/MyDrive/conveyor_with_rotation.mp4') #_
↳give the correct path here
while cap.isOpened():
    ret, frame = cap.read()
    if not ret:
        print("Can't receive frame (stream end?). Exiting ...")
        break
    col_frames.append(frame)
    frames.append(cv.cvtColor(frame, cv.COLOR_BGR2GRAY))
cap.release()
cv.destroyAllWindows()
frames = np.array(frames)
print("Frames shape:", frames.shape)
```

Can't receive frame (stream end?). Exiting ...
Frames shape: (280, 1080, 1920)

7.1 Drawing contours in each frame

Commented due to this taking around 2 minutes and continuously outputting images from each frame. (280 image outputs)

```
[253]: #for grey in frames:
#     retval, labels, stats, centroids = get_indexed_image(grey)
#     contours, hierarchy = cv.findContours(((labels >= 1)*255).astype('uint8'),_
↳cv.RETR_TREE, cv.CHAIN_APPROX_SIMPLE)
#     im_contours_belt = np.zeros((grey.shape[0],grey.shape[1],3), np.uint8)
#     conts = cv.drawContours(im_contours_belt, contours, -1, (0,255,0), 3).
↳astype('uint8')
#     plt.imshow(conts)
#     plt.show()
#     print()
```

7.2 Segmentation

Adding the contour_store to keep the bounding hexagons of each nut to be put in video.

```
[254]: object_flow = []
contour_store = []
```

```

matching_threshold = 4.5e-3
for grey in frames:
    retval, labels, stats, centroids = get_indexed_image(grey)
    contours, hierarchy = cv.findContours(((labels >= 1)*255).astype('uint8'), cv.
    ↳RETR_TREE, cv.CHAIN_APPROX_SIMPLE)
    frame_objects = []
    conts = []
    for i in range(len(contours)):
        if cv.matchShapes(contours_t[0], contours[i], cv.CONTOURS_MATCH_I1, 0.0) >
    ↳matching_threshold: continue
        ca = int(cv.contourArea(contours[i]))
        if ca<59500: continue
        M = cv.moments(contours[i])
        cx, cy = int(M['m10']/M['m00']), int(M['m01']/M['m00'])
        frame_objects.append([cx, cy, ca, i+1])
        conts.append(contours[i])
    frame_objects = np.array(frame_objects)
    contour_store.append(conts)
    object_flow.append(frame_objects)

```

7.3 Tracking

```

[255]: prev_frame = object_flow[0]
obj_count = object_flow[0].shape[0]
for frame in object_flow[1:]:
    for obj in frame:
        if is_new(prev_frame, obj, delta_x, 0):
            obj_count+=1
            obj[3] = obj_count
        else:
            obj[3] = prev_frame[prev_index(prev_frame, obj, delta_x, 0)][0, 3]
    prev_frame = frame

```

7.4 Adding text

In addition to putting the text label, a bounding hexagon for each nut and my index number are added to each frame.

```

[256]: for i in range(len(frames)):
    frame = col_frames[i]
    for obj in object_flow[i]:
        frame = cv.putText(frame, str(int(obj[3])), (int(obj[0]), int(obj[1])), cv.
    ↳FONT_HERSHEY_SIMPLEX, 2, (0,0,255), 2)
        frame = cv.putText(frame, '180616T', (20, 1060), cv.FONT_HERSHEY_SIMPLEX,
    ↳2, (0,0,255), 2)
        frame = cv.drawContours(frame, contour_store[i], -1, (0, 0, 255), 3).
    ↳astype(np.uint8)

```

8 Complete run for conveyor_with_rotation.mp4

```
[258]: import cv2 as cv
import numpy as np

print("Identification of objects in a video\nby 180616T-P.M.P.H. Somarathne")

def get_indexed_image(im):
    """
    Thresholding, closing, and connected component anysis lumped
    """
    th, img = cv.threshold(im, 0, 255, cv.THRESH_BINARY_INV + cv.THRESH_OTSU)
    kernel = np.ones((3,3), dtype=np.uint8)
    closing = cv.morphologyEx(img, cv.MORPH_CLOSE, kernel)
    retval, labels, stats, centroids = cv.connectedComponentsWithStats(closing)
    return retval, labels, stats, centroids

def is_new(a, b, delta, i):
    """
    Vector Dissimilarity with an Array of Vectors
    Checks if vector b is similar to a one or more vectors in a outside the
    →tolerances specified in delta.
    vector i specified which elements in b to compare with those in a
    """
    if (np.absolute(a[:,i] - b[i]) > delta).all(): return True
    return False

def prev_index(a, b, delta, i):
    """
    Returns Previous Index
    Returns the index of the appearance of the object in the previous frame
    """
    index = np.where(np.absolute(a[:,i] - b[i]) <= delta)
    return index[0]

# Detect contours of template.png to be used as reference
print("Reading template")
template_im = cv.imread(r'template.png', cv.IMREAD_GRAYSCALE)
th_t, img_t = cv.threshold(template_im, 0, 255, cv.THRESH_BINARY_INV + cv.
    →THRESH_OTSU)
kernel = np.ones((3,3), dtype=np.uint8)
closing_t = cv.morphologyEx(img_t, cv.MORPH_CLOSE, kernel)
contours_t, hierarchy_t = cv.findContours(closing_t, cv.RETR_TREE, cv.
    →CHAIN_APPROX_SIMPLE)

# Read the video
print("Reading video")
```

```

col_frames = []
frames = []
cap = cv.VideoCapture('/content/drive/MyDrive/conveyor_with_rotation.mp4') #_
    ↳give the correct path here
while cap.isOpened():
    ret, frame = cap.read()
    if not ret:
        print("Can't receive frame (stream end?). Exiting ...")
        break
    col_frames.append(frame)
    frames.append(cv.cvtColor(frame, cv.COLOR_BGR2GRAY))
cap.release()
cv.destroyAllWindows()
frames = np.array(frames)
print("Frames shape:", frames.shape)

# Generate object flow
print("Generating object flow")
object_flow = []
contour_store = []
matching_threshold = 4.5e-3
for grey in frames:
    retval, labels, stats, centroids = get_indexed_image(grey)
    contours, hierarchy = cv.findContours(((labels >= 1)*255).astype('uint8'), cv.
    ↳RETR_TREE, cv.CHAIN_APPROX_SIMPLE)
    frame_objects = []
    conts = []
    for i in range(len(contours)):
        if cv.matchShapes(contours_t[0], contours[i], cv.CONTOURS_MATCH_I1, 0.0) >_
        ↳matching_threshold: continue
        ca = int(cv.contourArea(contours[i]))
        if ca<59500: continue
        M = cv.moments(contours[i])
        cx, cy = int(M['m10']/M['m00']), int(M['m01']/M['m00'])
        frame_objects.append([cx, cy, ca, i+1])
        conts.append(contours[i])
    frame_objects = np.array(frame_objects)
    contour_store.append(conts)
    object_flow.append(frame_objects)

# Track the nut and assign identification number
print("Tracking the nuts")
delta_x = 15
prev_frame = object_flow[0]
obj_count = object_flow[0].shape[0]
for frame in object_flow[1:]:
    for obj in frame:

```

```

    if is_new(prev_frame, obj, 15, 0):
        obj_count+=1
        obj[3] = obj_count
    else:
        obj[3] = prev_frame[prev_index(prev_frame, obj, delta_x, 0)][0, 3]
    prev_frame = frame
print("Detected", obj_count, "nuts in the video")

# Add identification number into original image as text
print("Adding text")
for i in range(len(frames)):
    frame = col_frames[i]
    for obj in object_flow[i]:
        frame = cv.putText(frame, str(int(obj[3])), (int(obj[0]), int(obj[1])), cv.
↪FONT_HERSHEY_SIMPLEX, 2, (0,0,255), 2)
        frame = cv.putText(frame, '180616T', (20, 1060), cv.FONT_HERSHEY_SIMPLEX, 2,
↪(0,0,255), 2)
        frame = cv.drawContours(frame, contour_store[i], -1, (0, 255, 0), 5).
↪astype(np.uint8)

# Encoding the frames
print("Encoding")
file_name = '180616t_en2550_a05.mp4'
fourcc = cv.VideoWriter_fourcc(*'MP4V')
out = cv.VideoWriter(file_name, fourcc, 30.0, (1920, 1080), True)
for frame in col_frames:
    out.write(frame)

# Release everything if job is finished
out.release()
print("Identification complete. You can view", file_name)

```

```

Identification of objects in a video
by 180616T-P.M.P.H. Somarathne
Reading template
Reading video
Can't receive frame (stream end?). Exiting ...
Frames shape: (280, 1080, 1920)
Generating object flow
Tracking the nuts
Detected 5 nuts in the video
Adding text
Encoding
Identification complete. You can view 180616t_en2550_a05.mp4

```

[259]: