Assignment 05

July 6, 2021

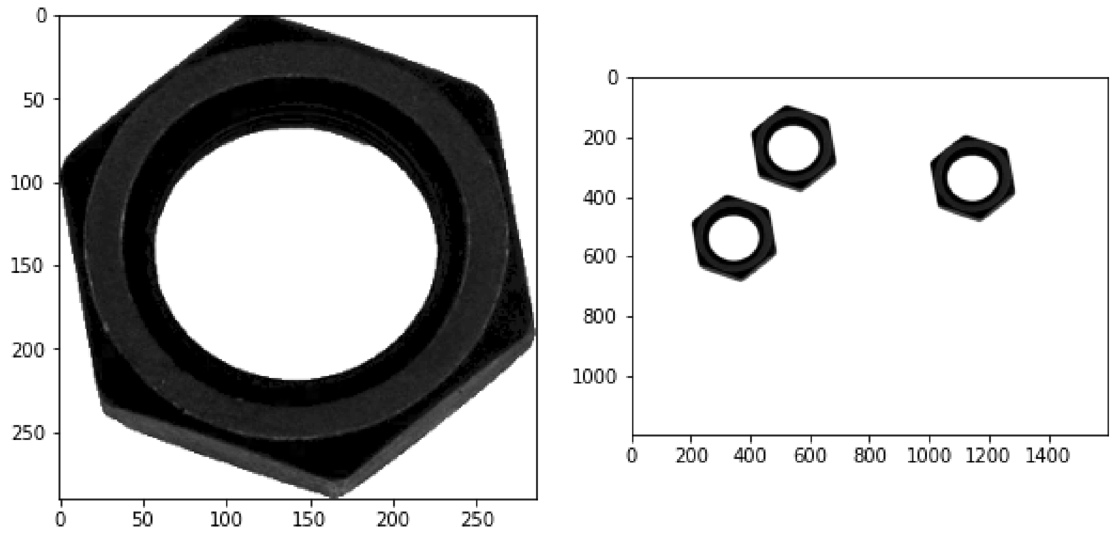
1 EN2550 Image Processing and Machine Vision - 2021

1.1 Assignment 05: Object Counting on a Conveyor Belt

1.1.1 180616T P.M.P.H. Somarathne

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

%matplotlib inline
```

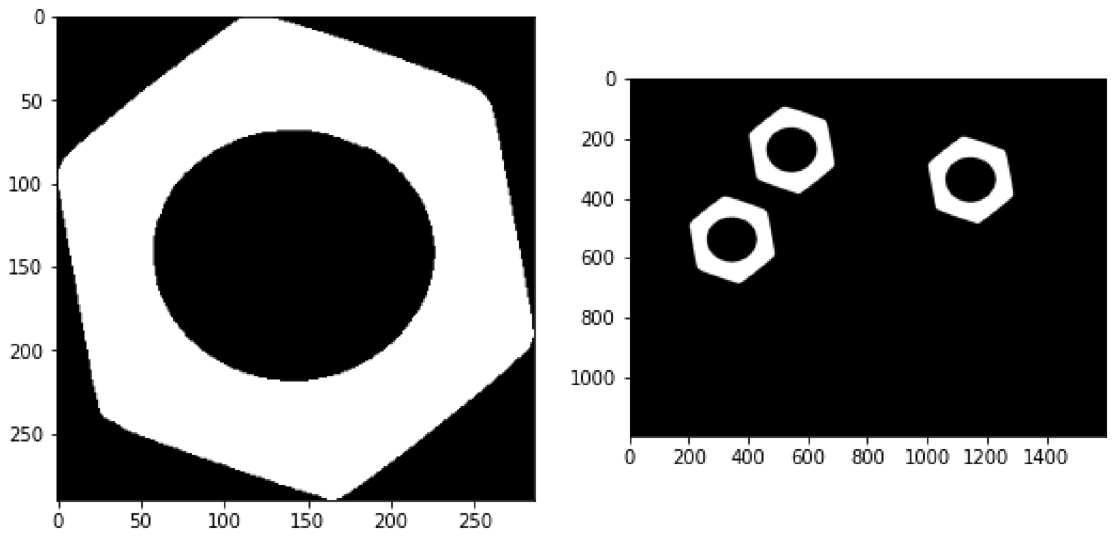
[227]:
```
template_im = cv.imread(r'template.png', cv.IMREAD_GRAYSCALE)
belt_im = cv.imread(r'belt.png', cv.IMREAD_GRAYSCALE)

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

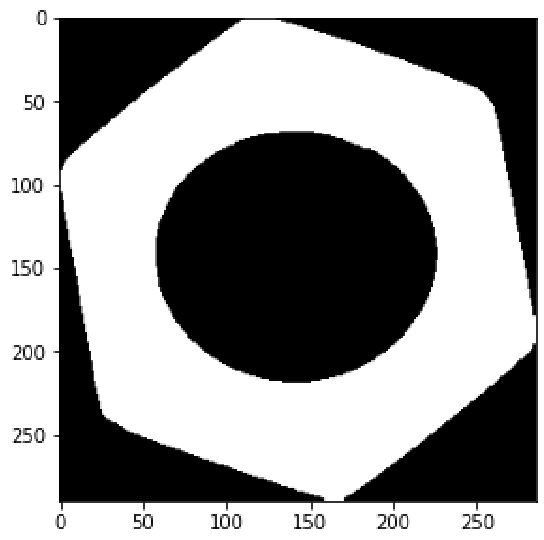
[228]:
```
th_t, img_t = cv.threshold(template_im, 0, 255, cv.THRESH_BINARY_INV + cv.
 ↪THRESH_OTSU)
th_b, img_b = cv.threshold(belt_im, 0, 255, cv.THRESH_BINARY_INV + cv.
 ↪THRESH_OTSU)
```

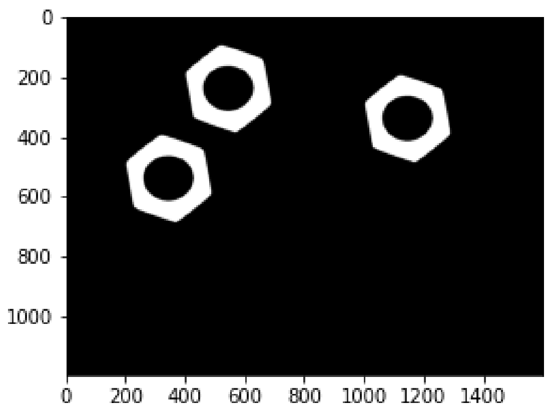
[229]:
```
fig, ax = plt.subplots(1, 2, figsize=(10,10))
ax[0].imshow(img_t, cmap='gray')
ax[1].imshow(img_b, cmap='gray')
plt.show()
```



[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)
```

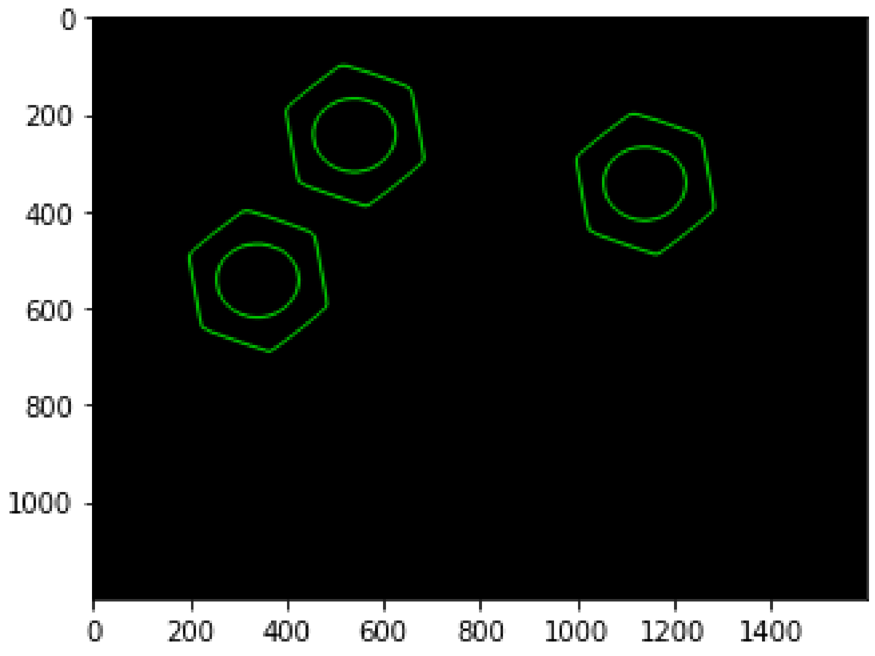
[233]:
```
print("Number of connected components on template:", np.unique(labels_t).
 ↪shape[0], "\nNumber of connected components on belt:", np.unique(labels_b).
 ↪shape[0], end='\n\n')
print("Stats for template:\n", stats_t, "\nStats for belt:\n", stats_b,␣
 ↪end='\n\n')
print("Centeroids of template:\n", centroids_t, "\nCentroids 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  ]]
Centroids 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]:
```python
ca = cv.contourArea(contours_b[1])
print(ca)
```

```
20080.0
```

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

```
341 542
```

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

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

4 PART III - GRADING

4.1 get_indexed_image function

[241]:
```python
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]:
```python
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

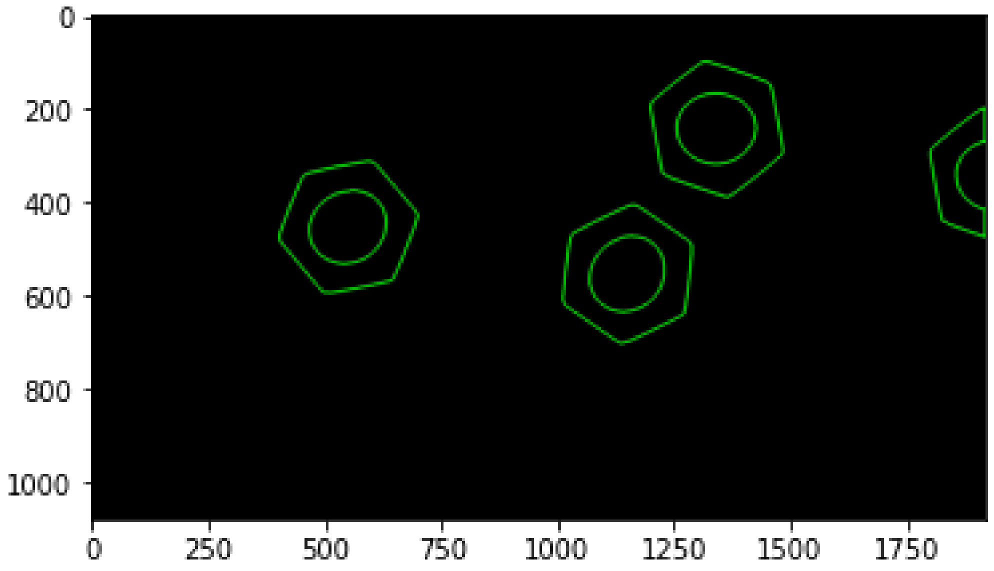
[260]:
```
col_frames = []
frames = []
cap = cv.VideoCapture('conveyor_two_frame.mp4') # give the correct path here
while cap.isOpened():
    ret, frame = cap.read()
    if not ret:
        print("Can't receive frame (stream end?). Exiting ...")
        break
    col_frames.append(frame)
    frames.append(cv.cvtColor(frame,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

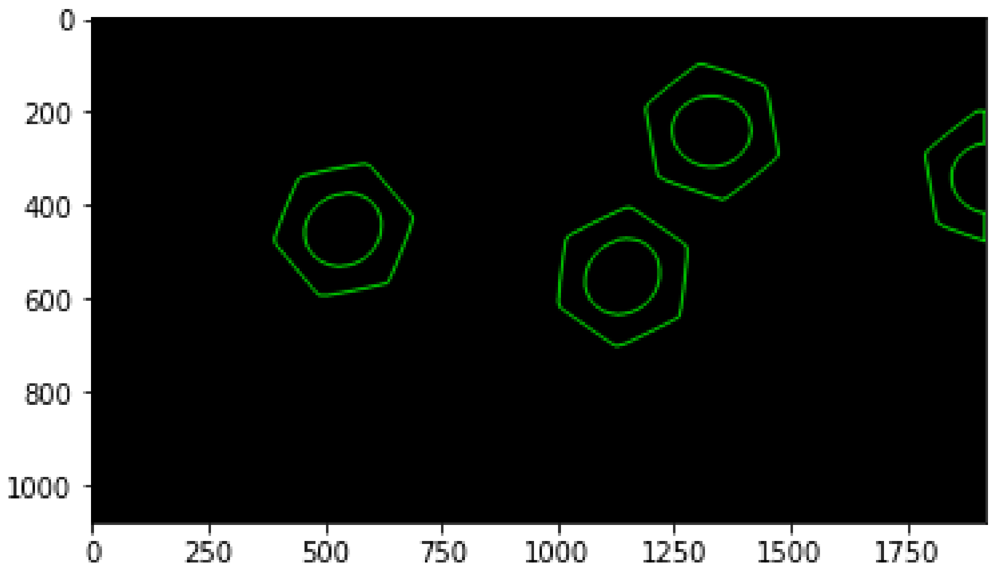
```
cv.destroyAllWindows()
frames = np.array(frames)
print("Frames shape:", frames.shape)
```

```
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]:
```python
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]:
```python
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]:
```python
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]:
```python
# 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

[254]:
```
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)
```

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

```
[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)
```

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 = []
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)

# 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, 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
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)

# 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]:
```
!du 180616t_en2550_a05.mp4
```

```
2280    180616t_en2550_a05.mp4
```

[259]:
```
```