In [1]:
```
import os
new_directory = 'D:\MSCS\CS455 Algorithm\Pattern Recognition'
os.chdir(new_directory)
```

In [14]:
```
os.getcwd()
```

Out[14]:
```
'D:\\MSCS\\CS455 Algorithm\\Pattern Recognition'
```

1. Noise reduction by blurring

a.Noise reduction is performed to distinguish the edge of each object in the image

b.Install OpenCV package

In [2]:
```
%matplotlib inline
import matplotlib.pyplot as plt
import cv2
import numpy as np
from IPython.display import display, Image
```

In [3]:
```
print(cv2.__version__)
```

```
4.8.0
```

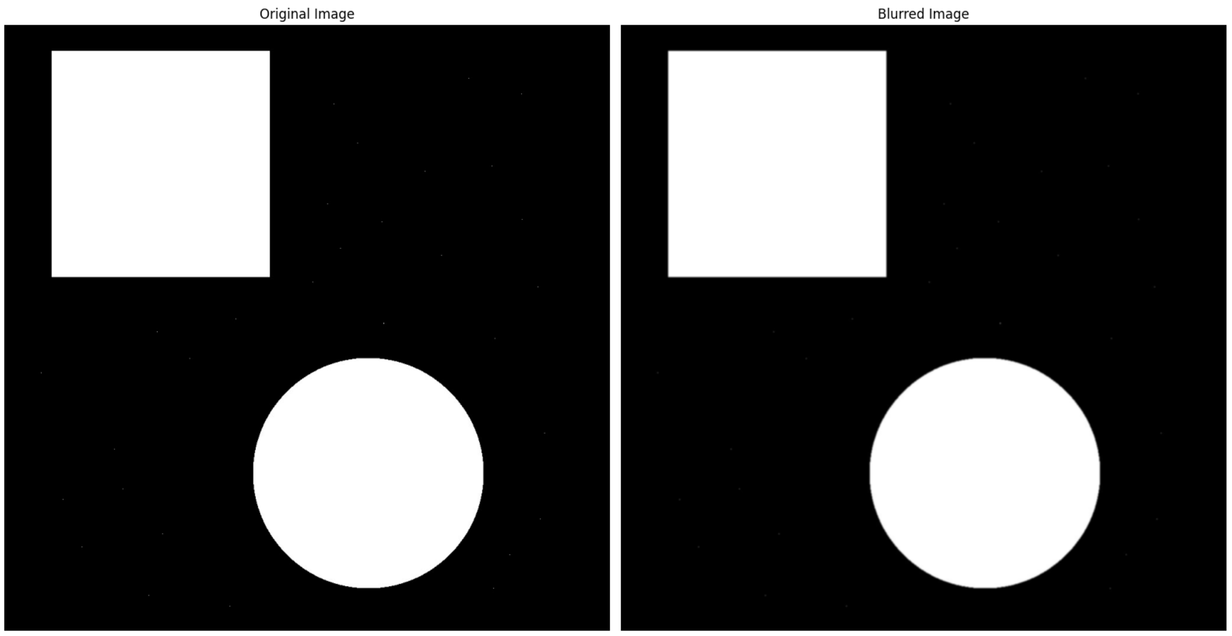
c.Noise reduction is performed by applying Gaussian Filter

In [13]:
```
image = cv2.imread('e_noise.jpg', cv2.IMREAD_GRAYSCALE)  # Load as grayscale
blurred_image = cv2.GaussianBlur(image, (5, 5), 0)

# Display original image
plt.figure(figsize=(16, 12))
plt.subplot(1, 2, 1)
plt.imshow(image, cmap='gray')
plt.title('Original Image')
plt.axis('off')

# Display blurred image
plt.subplot(1, 2, 2)
plt.imshow(blurred_image, cmap='gray')
plt.title('Blurred Image')
plt.axis('off')

plt.tight_layout()
plt.show()
```



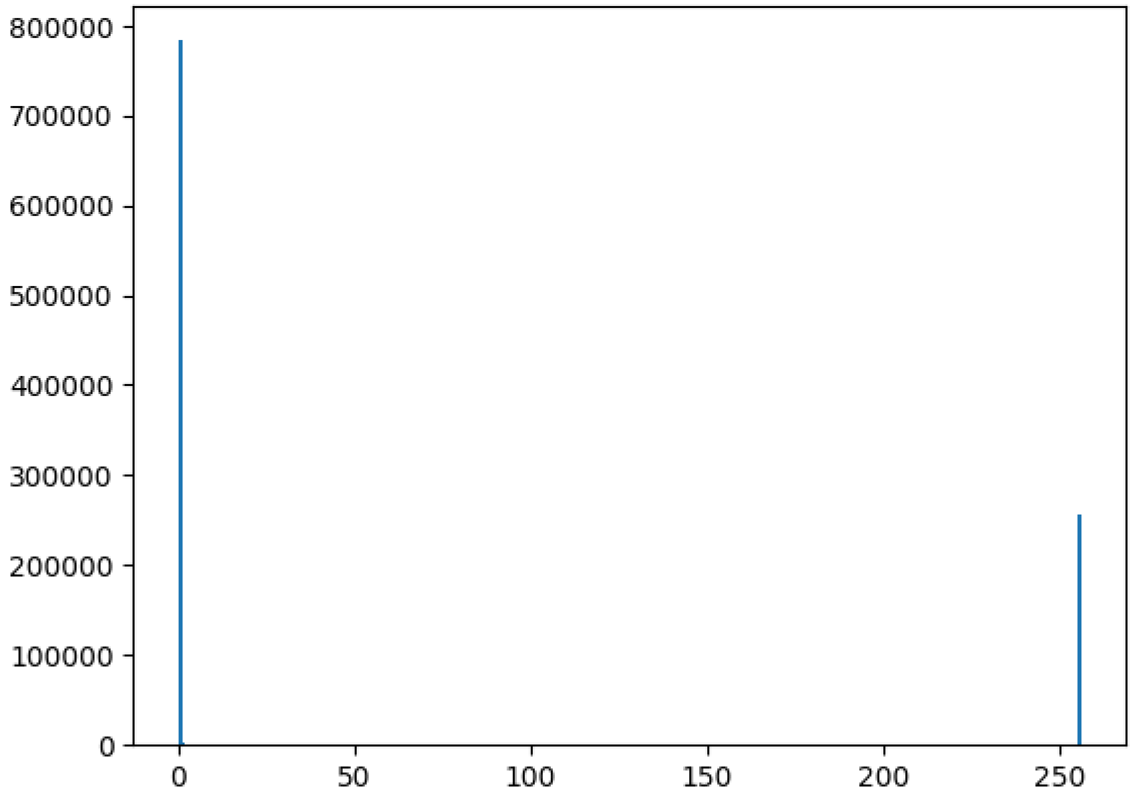
2. Histogram

a.Histogram is used to determine the threshold value that will be used for the next step

b.Create a code to plot histogram

In [27]:
```
from matplotlib import pyplot as plt
```

In [47]:
```
img = cv2.imread('e_noise.jpg',0)
plt.hist(img.ravel(),256,[0,256])
plt.show()
```



c.Explanation

plt.hist() finds the histogram and plot it

ravel() changes 2D/multi-dimensional array to contiguous flattened array

256 = number of pixels

d.Output

The output is shown in the above.

3. Thresholding

a.In Otsu's thresholding, it iterates through all possible threshold values and calculates the spread measurement for the pixel levels for each threshold. Its goal is to find the threhsold value where the sum of the foreground and background spreads are at the minimum

b.Added lines of code

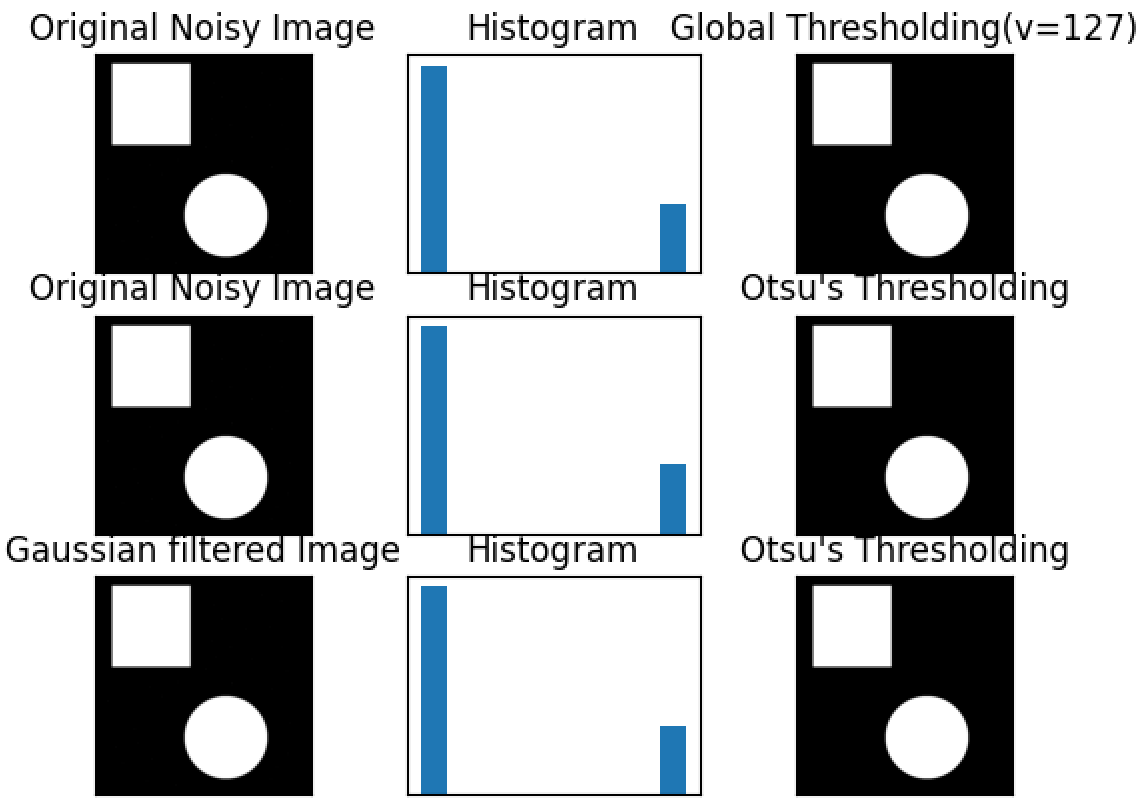
In [29]:
```
# Global thresholding
ret1,th1 = cv2.threshold(img,127,255,cv2.THRESH_BINARY)
```

In [30]:
```
# Otsu's thresholding
ret2,th2 = cv2.threshold(img,0,255,cv2.THRESH_BINARY+cv2.THRESH_OTSU)
```

In [42]:
```
# Otsu's thresholding after Gaussian filtering
blur = cv2.GaussianBlur(img,(5,5),0)
ret3,th3 = cv2.threshold(blur,0,255,cv2.THRESH_BINARY+cv2.THRESH_OTSU)
```

In [48]:
```
# plot all the images and their histograms
images = [img, 0, th1,
          img, 0, th2,
          blur, 0, th3]
titles = ['Original Noisy Image','Histogram','Global Thresholding(v=127)',
          'Original Noisy Image','Histogram',"Otsu's Thresholding",
          'Gaussian filtered Image','Histogram',"Otsu's Thresholding"]
```

In [50]:
```
for i in range(3):
    plt.subplot(3,3,i*3+1),plt.imshow(images[i*3],'gray')
    plt.title(titles[i*3]), plt.xticks([]), plt.yticks([])
    plt.subplot(3,3,i*3+2),plt.hist(images[i*3].ravel())
    plt.title(titles[i*3+1]), plt.xticks([]), plt.yticks([])
    plt.subplot(3,3,i*3+3),plt.imshow(images[i*3+2],'gray')
    plt.title(titles[i*3+2]), plt.xticks([]), plt.yticks([])
plt.show()
```



c.Explanation

threshold() applies fixed-level thresholding to a multiple-channel array. It is typically used to get a binary image out of a grayscale image or for removing noise by filtering out pixels with too small or too large values.

THRESH_BINARY

$$dst(x,y) = \begin{cases} maxval, & \text{if } src(x,y) > thresh \\ 0, & otherwise \end{cases}$$

THRES_OTSU uses the Otsu algorithm to choose the optimal threshold value. It is implemented only for 8-bit single-channel images.

Gaussianblur() blurs an image using a Gaussian filter, like we used in Step 1.

d.Output

The output is shown above.

4. Connectivity Analysis

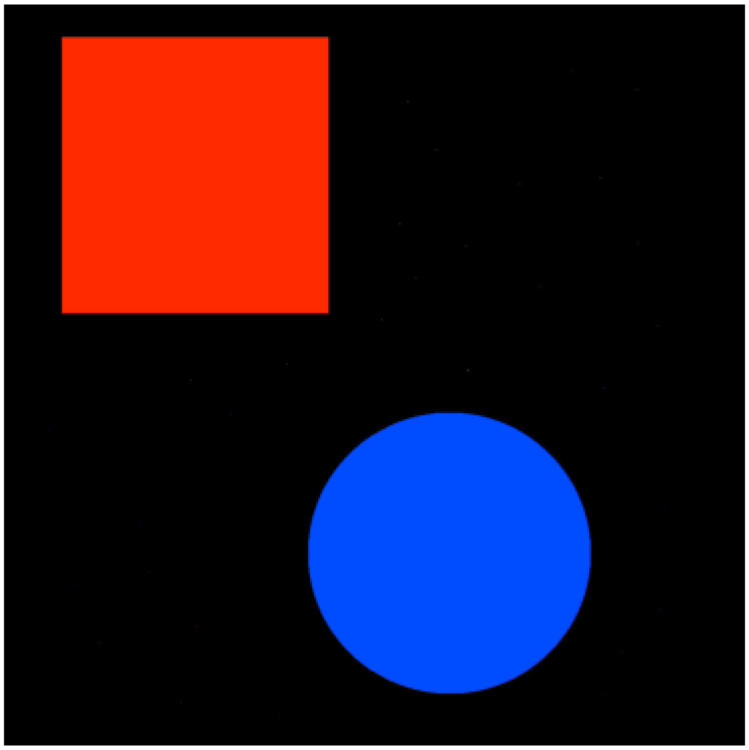
a.This step distinguishes separate objects in an image by using either a 4-pixel or 8-pixel connectivity. 4-pixel connects pixels with the same value along the edges. 8-pixel does the same with the addition of edges and corners.

b.Added lines of code

In [53]:
```
def connected_component_label(path):
 # Getting the input image
    img = cv2.imread('e_noise.jpg', 0)
 # Converting those pixels with values 1-127 to 0 and others to 1
    img = cv2.threshold(img, 127, 255, cv2.THRESH_BINARY)[1]
 # Applying cv2.connectedComponents()
    num_labels, labels = cv2.connectedComponents(img)
 # Map component labels to hue val, 0-179 is the hue range in OpenCV
    label_hue = np.uint8(179*labels/np.max(labels))
    blank_ch = 255*np.ones_like(label_hue)
    labeled_img = cv2.merge([label_hue, blank_ch, blank_ch])
 # Converting cvt to BGR
    labeled_img = cv2.cvtColor(labeled_img, cv2.COLOR_HSV2BGR)
 # set bg label to black
    labeled_img[label_hue==0] = 0
 #Showing Image after Component Labeling
    plt.imshow(cv2.cvtColor(labeled_img, cv2.COLOR_BGR2RGB))
    plt.axis('off')
    plt.title("Image after Component Labeling")
    plt.show()

img = cv2.imread('e_noise.jpg', 0)
connected_component_label(img)
```

Image after Component Labeling



c.Explanation

The above uses a classical algorithm with makes two passes. First to record equivalences and assign temporary labels. Second to replace the temporary labels with the label of its equivalent class.

d.Output

The results are shown above. Different objects are assigned different colors.

5. Pattern Recognition

a.This step is to recognize what kind of objects are in the picture

b.Install

```
In [56]: !pip install cvlib
```

```
Collecting cvlib
  Downloading cvlib-0.2.7.tar.gz (13.1 MB)
     ---------------------------------------- 13.1/13.1 MB 4.4 MB/s eta 0:00:00
  Preparing metadata (setup.py): started
  Preparing metadata (setup.py): finished with status 'done'
Requirement already satisfied: numpy in c:\users\odody\anaconda3\lib\site-packages (f
rom cvlib) (1.23.5)
Collecting progressbar
  Downloading progressbar-2.5.tar.gz (10 kB)
  Preparing metadata (setup.py): started
  Preparing metadata (setup.py): finished with status 'done'
Requirement already satisfied: requests in c:\users\odody\anaconda3\lib\site-packages
(from cvlib) (2.28.1)
Requirement already satisfied: pillow in c:\users\odody\anaconda3\lib\site-packages
(from cvlib) (9.4.0)
Requirement already satisfied: imageio in c:\users\odody\anaconda3\lib\site-packages
(from cvlib) (2.26.0)
Collecting imutils
  Downloading imutils-0.5.4.tar.gz (17 kB)
  Preparing metadata (setup.py): started
  Preparing metadata (setup.py): finished with status 'done'
Requirement already satisfied: charset-normalizer<3,>=2 in c:\users\odody\anaconda3\l
ib\site-packages (from requests->cvlib) (2.0.4)
Requirement already satisfied: idna<4,>=2.5 in c:\users\odody\anaconda3\lib\site-pack
ages (from requests->cvlib) (3.4)
Requirement already satisfied: urllib3<1.27,>=1.21.1 in c:\users\odody\anaconda3\lib
\site-packages (from requests->cvlib) (1.26.14)
Requirement already satisfied: certifi>=2017.4.17 in c:\users\odody\anaconda3\lib\sit
e-packages (from requests->cvlib) (2022.12.7)
Building wheels for collected packages: cvlib, imutils, progressbar
  Building wheel for cvlib (setup.py): started
  Building wheel for cvlib (setup.py): finished with status 'done'
  Created wheel for cvlib: filename=cvlib-0.2.7-py3-none-any.whl size=10046378 sha256
=8756fe4184a4b3187f6d895c8057eb7b8ca1aa071bc46f8df4673c4c51f9c884
  Stored in directory: c:\users\odody\appdata\local\pip\cache\wheels\2c\b4\91\c6ddd31
550a14fec141d21053f4a6fe5729c41aaf991baf2bc
  Building wheel for imutils (setup.py): started
  Building wheel for imutils (setup.py): finished with status 'done'
  Created wheel for imutils: filename=imutils-0.5.4-py3-none-any.whl size=25854 sha25
6=3053c58e8d225c9180c7a525122cb8869f40dbb7e56e968af978d8b1ba06a149
  Stored in directory: c:\users\odody\appdata\local\pip\cache\wheels\c2\02\32\f3617a9
f68bcc67eda3ebeb4514eba18f62e81ff439428109d
  Building wheel for progressbar (setup.py): started
  Building wheel for progressbar (setup.py): finished with status 'done'
  Created wheel for progressbar: filename=progressbar-2.5-py3-none-any.whl size=12084
sha256=5b7b28a7e7d40b4cd6d5f6af511dfcc9c3b24a2b384d8febbc3d1b0a4ecf0565
  Stored in directory: c:\users\odody\appdata\local\pip\cache\wheels\87\80\e5\ebb505e
651c0099350734492f23bea3f5ad466275f78448b9d
Successfully built cvlib imutils progressbar
Installing collected packages: progressbar, imutils, cvlib
Successfully installed cvlib-0.2.7 imutils-0.5.4 progressbar-2.5
```

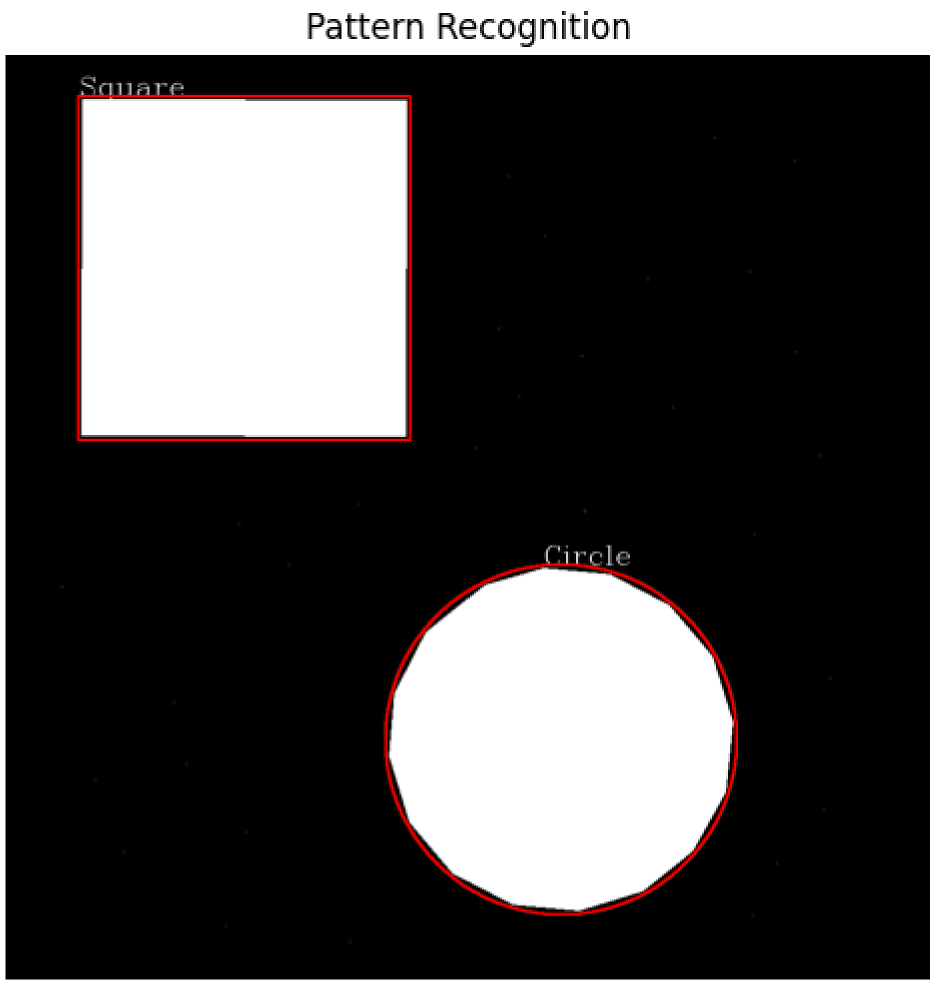
c.Added lines of code

In [11]:
```
img = cv2.imread('e_noise.jpg', cv2.IMREAD_GRAYSCALE)
blur = cv2.GaussianBlur(img,(5,5),0)
font = cv2.FONT_HERSHEY_COMPLEX
_, threshold = cv2.threshold(blur,0,255,cv2.THRESH_BINARY+cv2.THRESH_OTSU)
contours, _ = cv2.findContours(threshold, cv2.RETR_TREE, cv2.CHAIN_APPROX_SIMPLE)
```

```
for cnt in contours:
    approx = cv2.approxPolyDP(cnt, 0.01*cv2.arcLength(cnt, True), True)
    cv2.drawContours(blur, [approx], 0, (0), 5)
    x = approx.ravel()[0]
    y = approx.ravel()[1]
    if len(approx) == 4:
        cv2.putText(blur, "Square", (x,y), font, 1, (255))
    else:
        cv2.putText(blur, "Circle", (x,y), font, 1, (255))

img_bgr = cv2.cvtColor(blur, cv2.COLOR_GRAY2BGR)
cv2.drawContours(img_bgr, contours, -1, (255,0,0), 2)

plt.figure(figsize=(8, 6))
plt.imshow(img_bgr)
plt.title('Pattern Recognition')
plt.axis('off')
plt.show()
```



d.Explanation

Threshold was used to get a black and white image, then the contours or boundaries of the shapes were found. Using the contours, the coordinates for each shape is known. By approximating the contours, we can find the name of the shape of the object.

len(approx) == ?? can be changed into different numbers (e.g. 3 for Triangle)

6 < len(approx) < 15 is for ellipse or oval

img = cv2.cvtColor(img, cv2.COLOR_GRAY2BGR) is to convert the black and white image and contour back to colored

e.Output
The output is shown above.

Reference:

Histogram
https://opencv-pythontutroals.readthedocs.io/en/latest/py_tutorials/py_imgproc/py_histograms/py_histogram_begi
Threshold
https://opencv-pythontutroals.readthedocs.io/en/latest/py_tutorials/py_imgproc/py_thresholding/py_thresholding.h
https://docs.opencv.org/master/d7/d1b/group__imgproc__misc.html#ggaa9e58d2860d4afa658ef70
Connectivity analysis
https://iq.opengenus.org/connected-component-labeling/

https://github.com/yashml/OpenGenus_Articles_Code/tree/master/Connected%20Component%20L
Pattern recognition
https://pysource.com/2018/09/25/simple-shape-detection-opencv-with-python-3/

```
In [ ]:
```