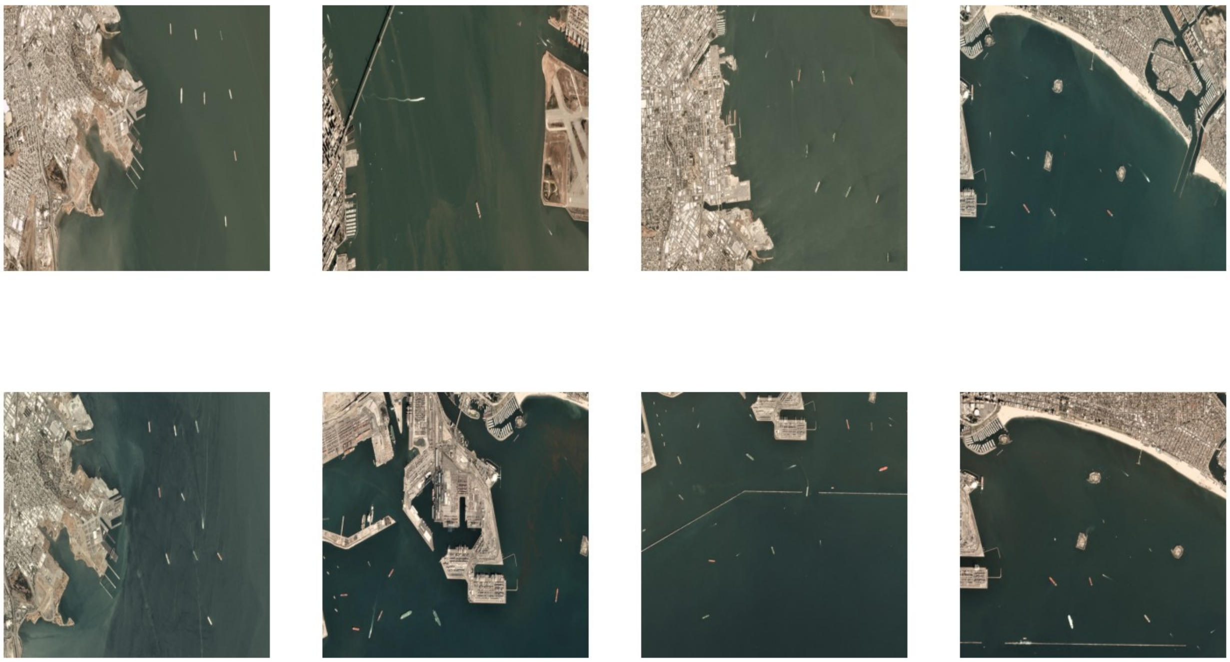
```python
## Importing necessary modules

import numpy as np
import matplotlib.pyplot as plt
import cv2 as cv
import os
from math import floor

## This is a helper function for plotting the images and feature maps
## for detailed representation

def plot_images(images, title, cmap=None):
  plt.figure(figsize=(12, 7), dpi=150)
  plt.suptitle(title)
  for idx, image in enumerate(images):
    plt.subplot(int(f"24{idx+1}"))

    if cmap=='gray':
      plt.imshow(image, cmap=cmap)
    else:
      plt.imshow(image)
    plt.axis("off")

## This part of the code is used to load the dataset in
## different color spectrums such as RGB, HSV and Gray
## and resize the images into a shape of (1000, 1000)

path = "/content/Dataset"

def load_images(path, gray=False, color=None):
  images = []
  for img in os.listdir(path):
    img = cv.imread(os.path.join(path, img))

    if color==None:
      img = cv.cvtColor(img, cv.COLOR_BGR2RGB)

    elif color=='HSV':
      img = cv.cvtColor(img, cv.COLOR_BGR2HSV)

    if gray:
      img = cv.cvtColor(img, cv.COLOR_BGR2GRAY)

    img = cv.resize(img, (1000,1000))
    images.append(img)

  return images

## Loading the dataset an viewing it with help of the
## helper functions mentioned above
```

```
images = load_images(path)
plot_images(images, "Dataset")
```

Dataset

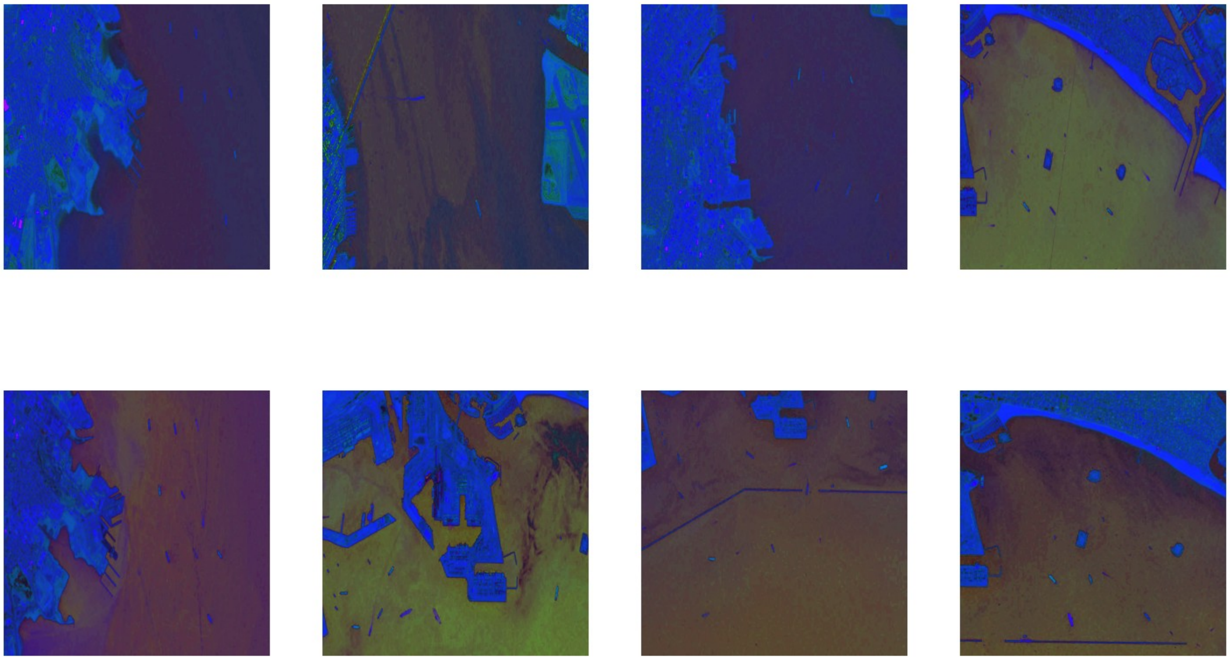


Applying Canny Edge Detection

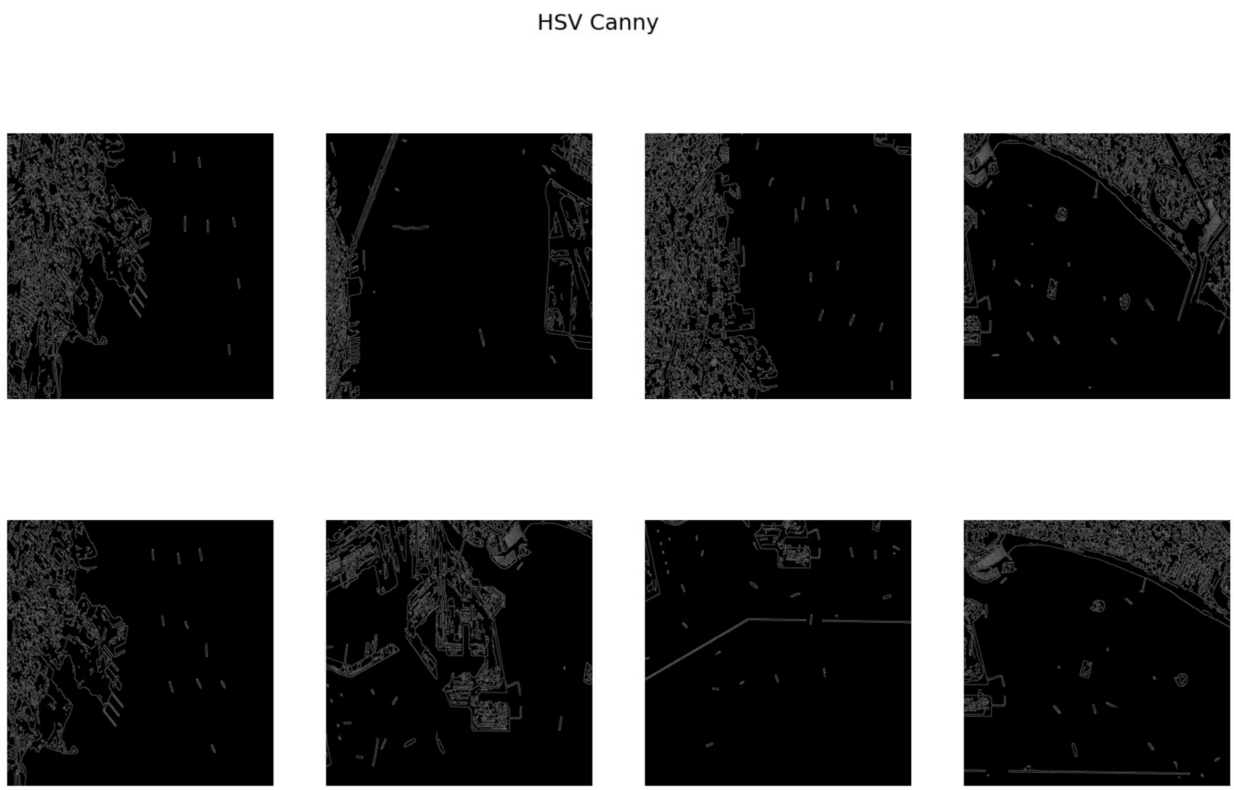
Using HSV Spectrum

```
## Loading the images in HSV format and viewing it for comparing
## them with regular RGB images, to see if there is any difference.
## HSV images helped us a lot in differentiating the water bodies
## from other objects in the images.

hsv_images = load_images(path, color='HSV', gray=False)
plot_images(hsv_images, title="HSV Images")
```

HSV Images

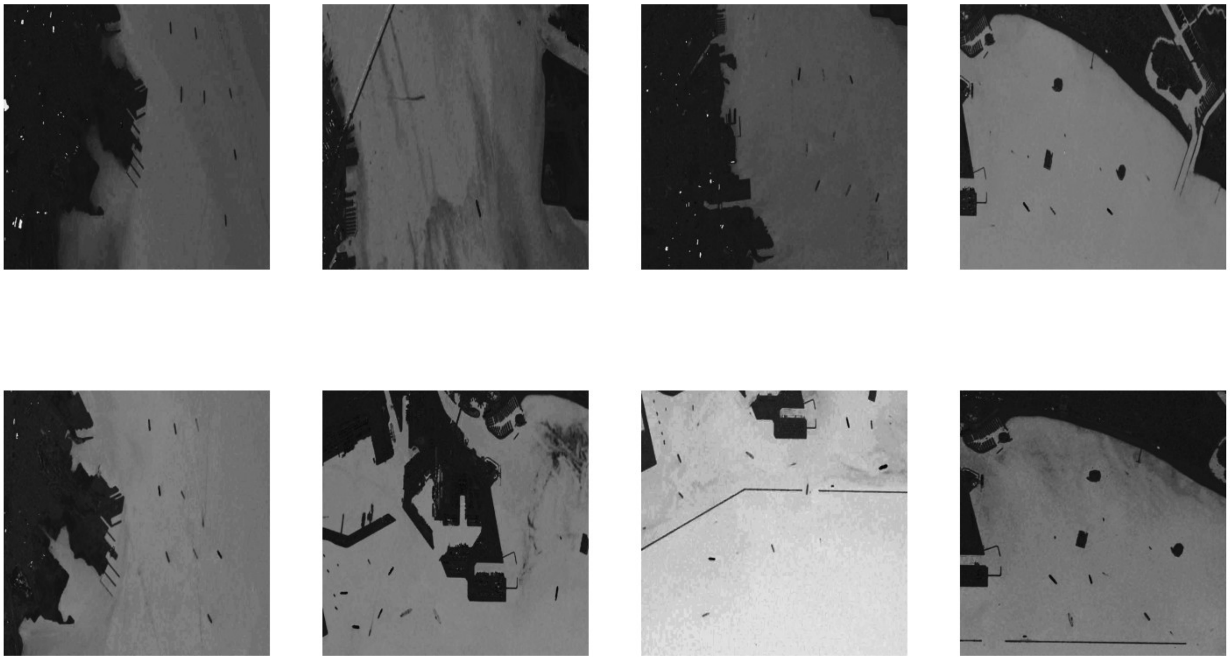


```
## Applyin GaussinBlur and Canny Edge Detection on the HSV images
## to recognize the edges and objects in the figure. This later helped
## us in seperating water bodies with other objects.

hsv_blur = [cv.GaussianBlur(image, (11,11), 0) for image in hsv_images]
canny_hsv = [cv.Canny(image, 10, 100) for image in hsv_blur]
plot_images(canny_hsv, title="HSV Canny", cmap="gray")
```



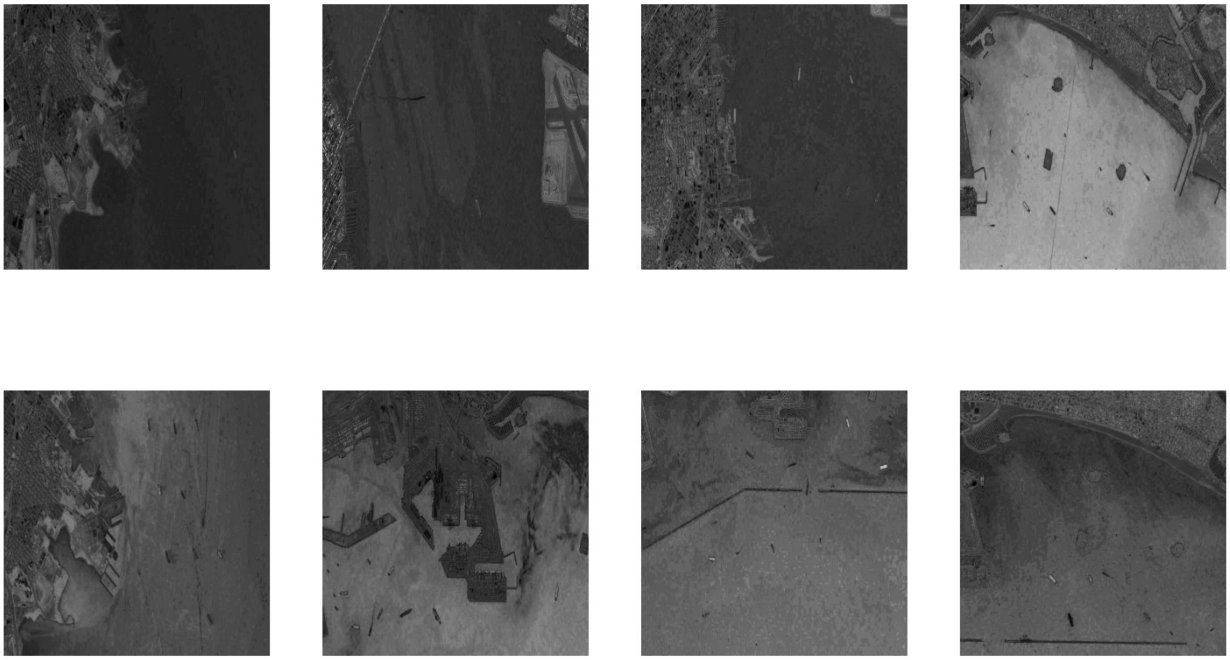

```
## median_smooth function is completely custom image smoothing
## techniques that applies median smoothing on the images. We
## are planning to implement this on the final feature maps or
## predictions to remove any noise present in them.

def median_smooth(feature_map, kernel_size=3, pad=True, stride=1):
  n = feature_map.shape[0]
  padding = kernel_size - 2
  op = floor((n + (2 * padding) - kernel_size) / stride) + 1
  output = np.zeros((op, op), dtype=np.uint8)
  feature_map = np.pad(feature_map, padding, 'reflect')
  for row in range(op):
    for col in range(kernel_size-1, op):
      median = np.median(feature_map[row, col])
      output[row, col] = median

  return output

## Plotting the H cahnnel in HSV image to if we can gain any
information.

plot_images([
    image[:,:,0]
    for image in hsv_images
], title="H in HSV Spectrum", cmap='gray')
```

H in HSV Spectrum



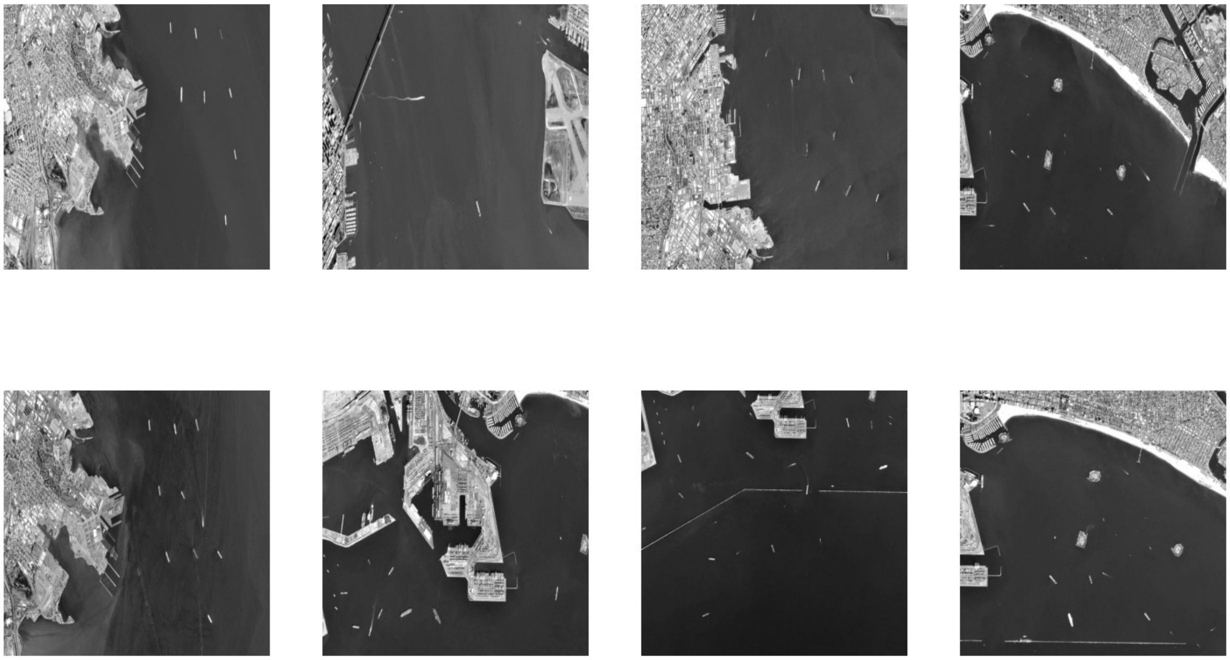
```python
## Plotting the S cahnnel in HSV image to if we can gain any
information.

plot_images([
    image[:,:,1]
    for image in hsv_images
], title="S in HSV Spectrum", cmap='gray')
```

S in HSV Spectrum



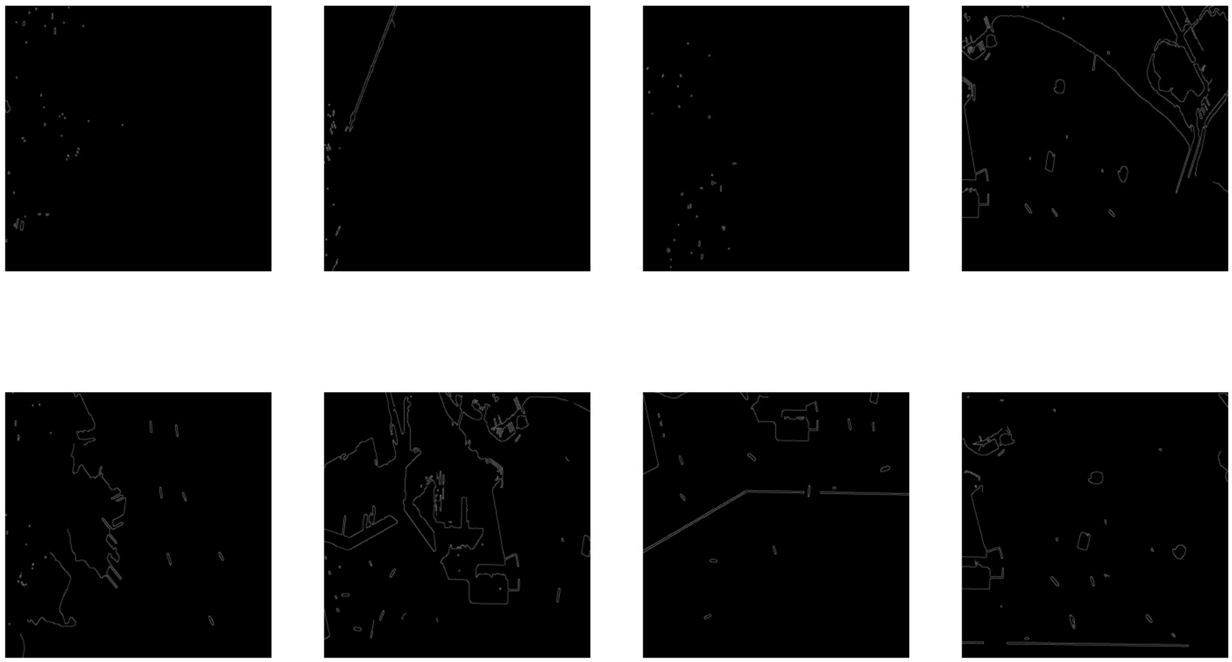
```
## Plotting the V cahnnel in HSV image to if we can gain any
information.

plot_images([
    image[:,:,2]
    for image in hsv_images
], title="V in HSV Spectrum", cmap='gray')
```

V in HSV Spectrum

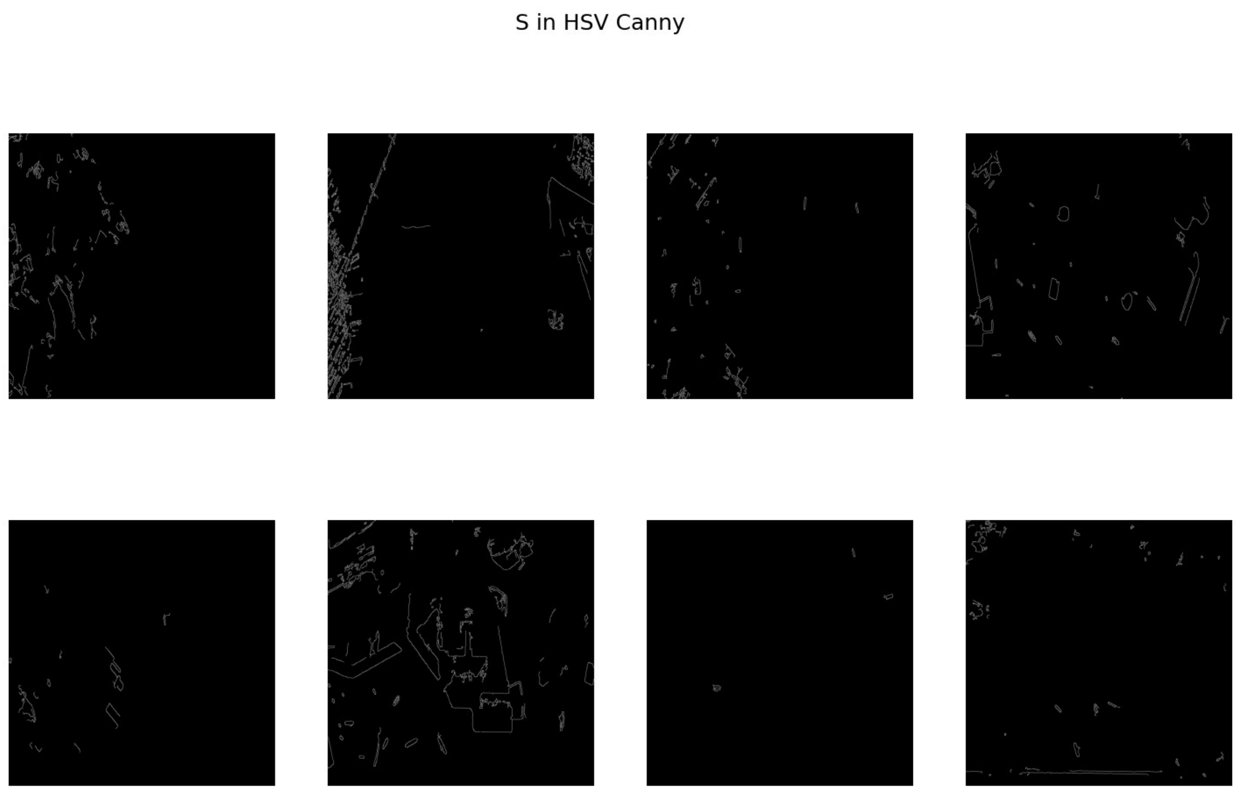


```
## Applying Gaussian Blur and Canny Edge Detection on the H channel of the images

H_blur = [cv.GaussianBlur(image[:,:,0], (9,9), 0) for image in hsv_images]
canny_H = [cv.Canny(image, 10, 100) for image in H_blur]
plot_images(canny_H, title="H in HSV Canny", cmap="gray")
```

H in HSV Canny

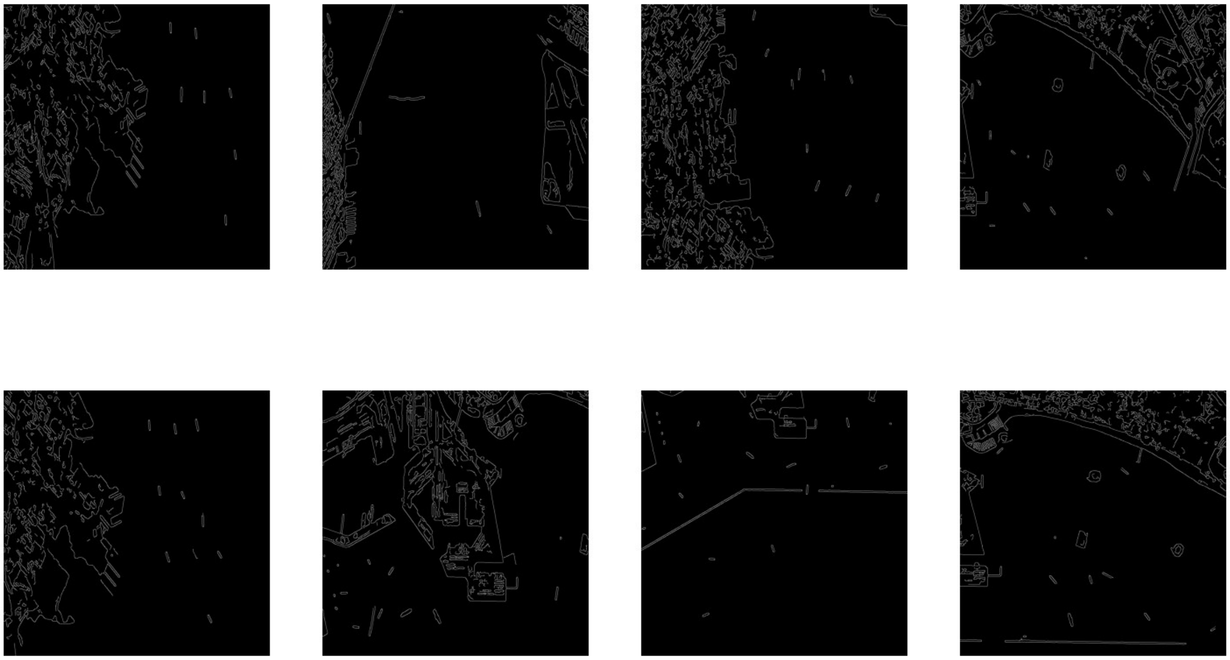


```
## Applying Gaussian Blur and Canny Edge Detection on the S channel of the images

S_blur = [cv.GaussianBlur(image[:,:,1], (9,9), 0) for image in hsv_images]
canny_S = [cv.Canny(image, 10, 100) for image in S_blur]
plot_images(canny_S, title="S in HSV Canny", cmap="gray")
```



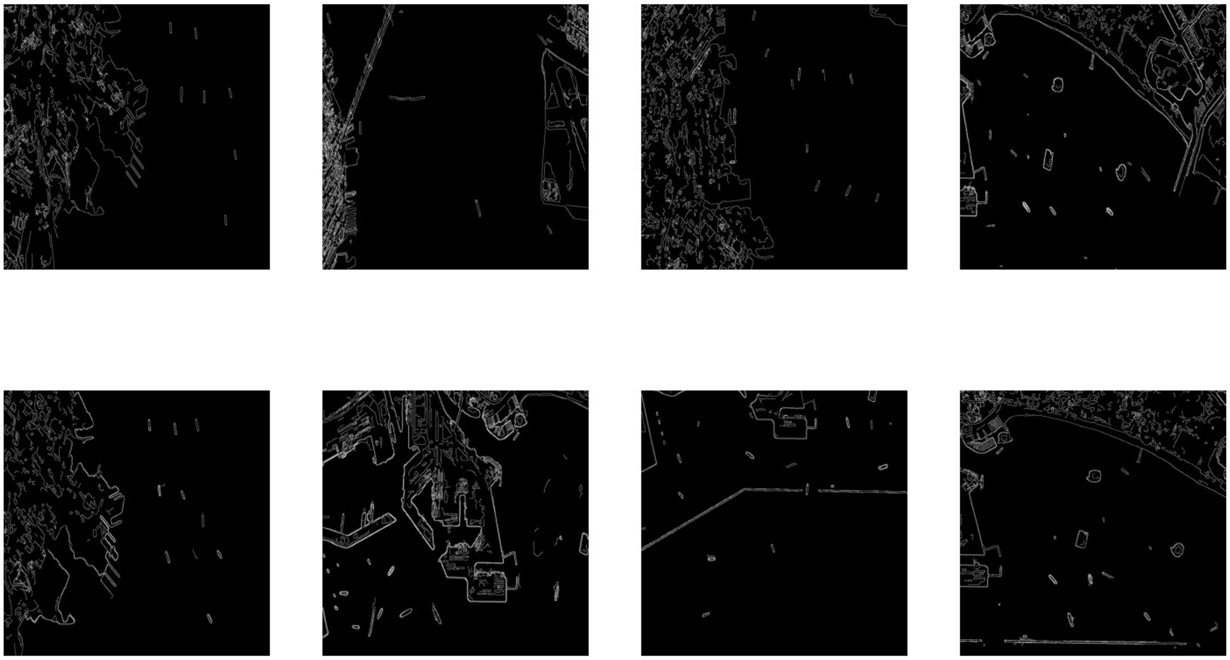
```
## Applying Gaussian Blur and Canny Edge Detection on the V channel of the images

V_blur = [cv.GaussianBlur(image[:,:,2], (15,15), 0) for image in hsv_images]
canny_V = [cv.Canny(image, 10, 100) for image in V_blur]
plot_images(canny_V, title="V in HSV Canny", cmap="gray")
```

V in HSV Canny



```
## COmbining the feature maps from the Canny Edge Detection of H,S and
V
## channels by super imposing them on each other. This gave us the
final
## Edge Detection map shown below.

HSV_canny = zip(canny_H, canny_S, canny_V)
HSV_canny = [
    np.clip(sum(list(HSV)), 0, 1)
    for HSV in HSV_canny
]

plot_images(HSV_canny, title="Canny HSV", cmap='gray')
```

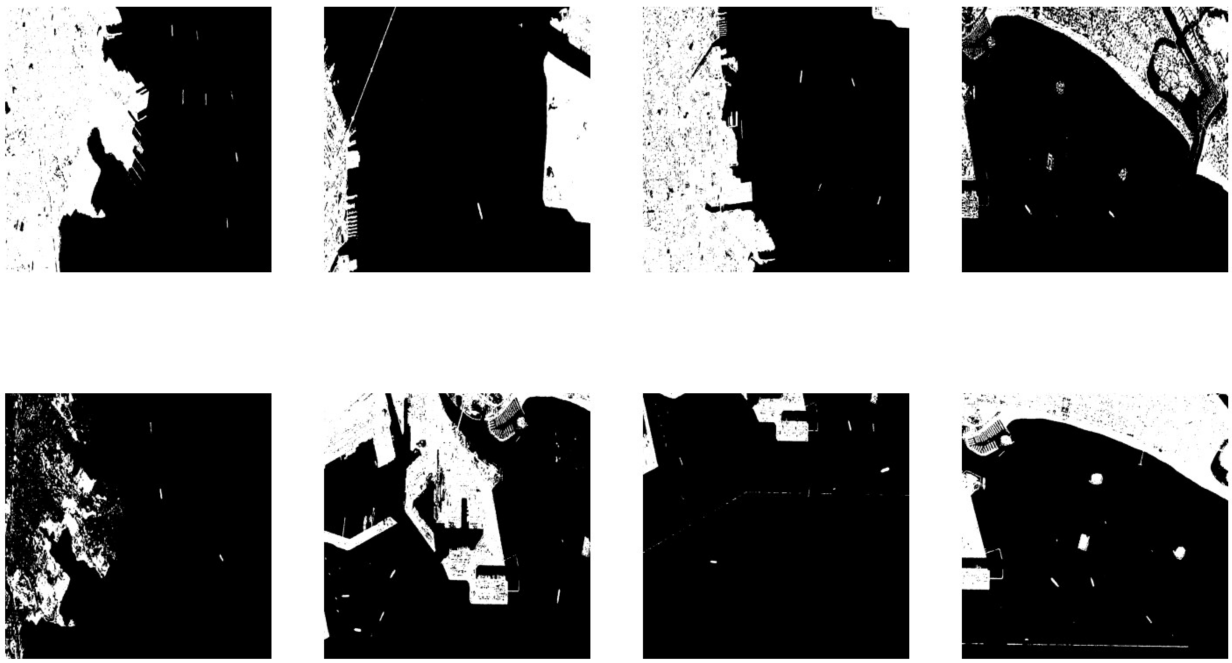
Canny HSV



Applying Thresholding

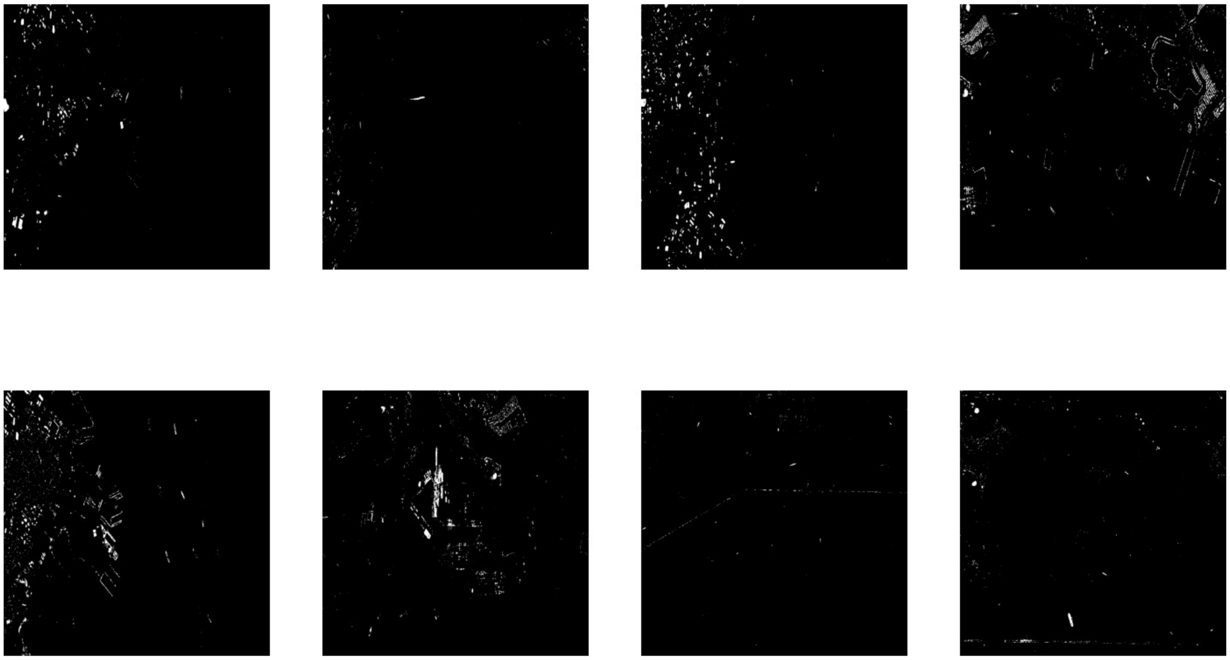
```
## The edge detection on H,S and V channels gave better results, so
## we are moving forward in that direction. No we have applied
thresholding
## on seperate channles of HSV and clipped then in that range.


## This part of the code clips H channl in the range of [0 - 20]

plot_images([
    image[:,:,0] < 20
    for image in hsv_images
], title="Thresholding H in HSV Spectrum", cmap='gray')
```

Thresholding H in HSV Spectrum



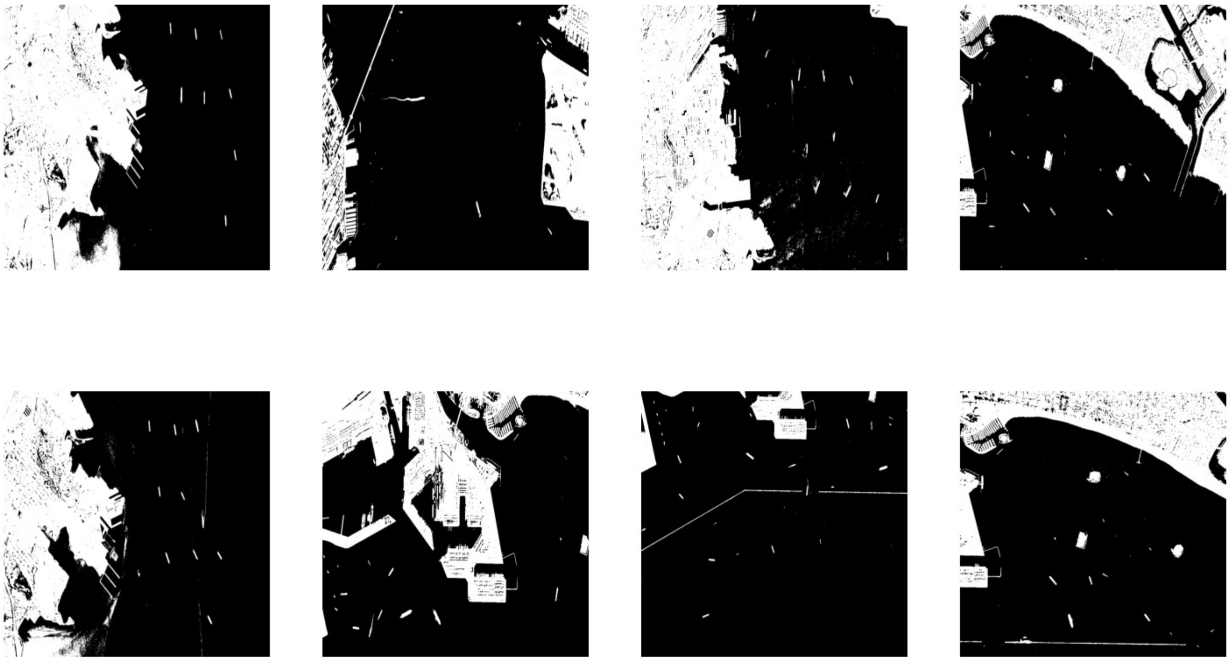
```
## This part of the code clips S channl in the range of [0 - 25]
plot_images([
    image[:,:,1] < 25
    for image in hsv_images
], title="Thresholding S in HSV Spectrum", cmap='gray')
```

Thresholding S in HSV Spectrum

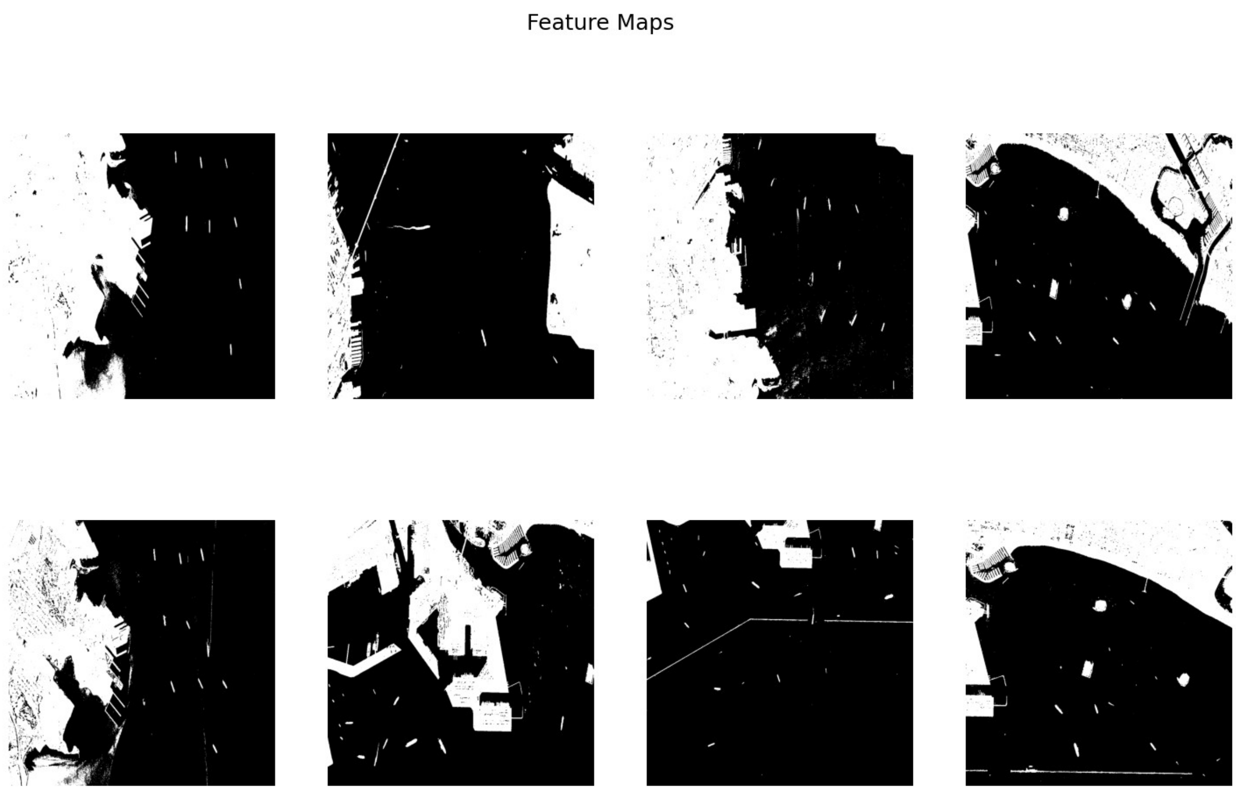


```python
## This part of the code clips H channl in the range of [100 - 255]

plot_images([
    image[:,:,2] > 100
    for image in hsv_images
], title="Thresholding V in HSV Spectrum", cmap='gray')
```

Thresholding V in HSV Spectrum



```
## We are combining the thresholded feature maps of each channel
## by super imposing them on each other. This gave us the final
## feature maps.

feature_maps = []
for image in hsv_images:
  map = (image[:,:,0] < 20) + (image[:,:,1] < 25) + (image[:,:,2] >
100)
  map = np.clip(map, 0, 1)
  feature_maps.append(map)


plot_images(feature_maps, title="Feature Maps", cmap='gray')
```



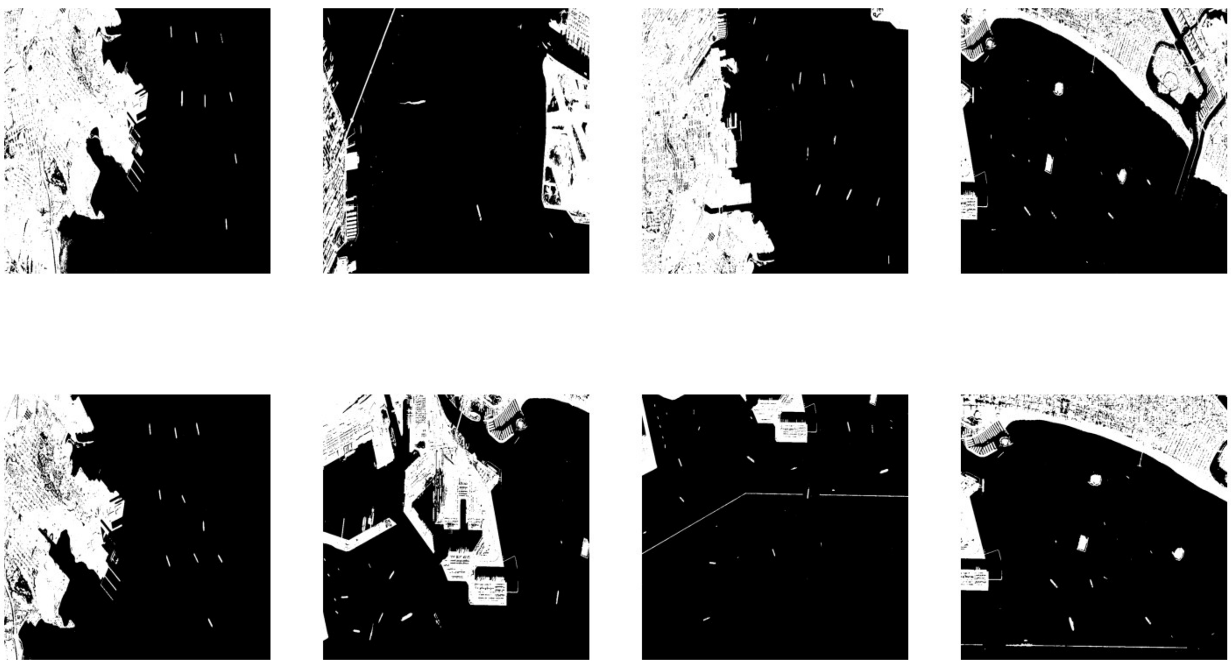

```python
from sklearn.cluster import KMeans

kmeans = dict()
data = np.array(hsv_images)
data = data.reshape((-1, 3))
preds = dict()
for i in range(2, 6):
  kmeans[i] = KMeans(n_clusters=i)
  kmeans[i].fit(data)
  preds[i] = kmeans[i].predict(data)
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/
_kmeans.py:870: FutureWarning: The default value of `n_init` will
change from 10 to 'auto' in 1.4. Set the value of `n_init` explicitly
to suppress the warning
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870
: FutureWarning: The default value of `n_init` will change from 10 to
'auto' in 1.4. Set the value of `n_init` explicitly to suppress the
warning
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870
: FutureWarning: The default value of `n_init` will change from 10 to
'auto' in 1.4. Set the value of `n_init` explicitly to suppress the
warning
  warnings.warn(
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870
: FutureWarning: The default value of `n_init` will change from 10 to
'auto' in 1.4. Set the value of `n_init` explicitly to suppress the
warning
  warnings.warn(
```

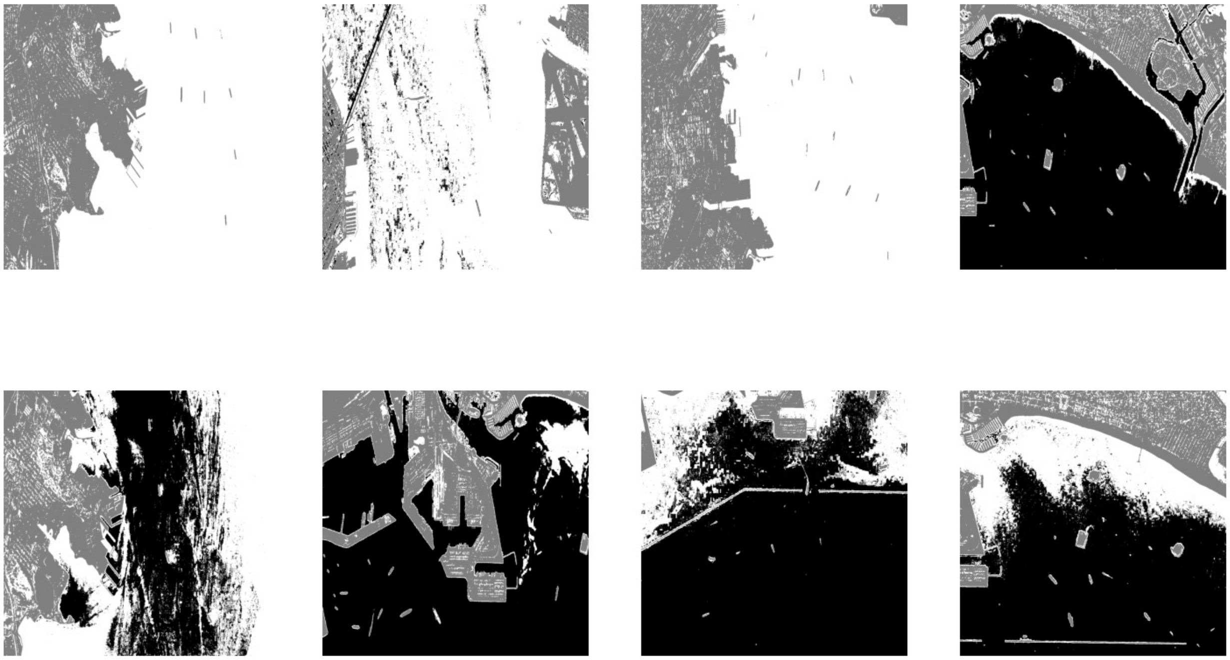
```
# preds[2] = preds[2] -1
plot_images(preds[2].reshape((8,1000,1000)), title="KMeans with 2
Clusters", cmap='gray')
```

KMeans with 2 Clusters



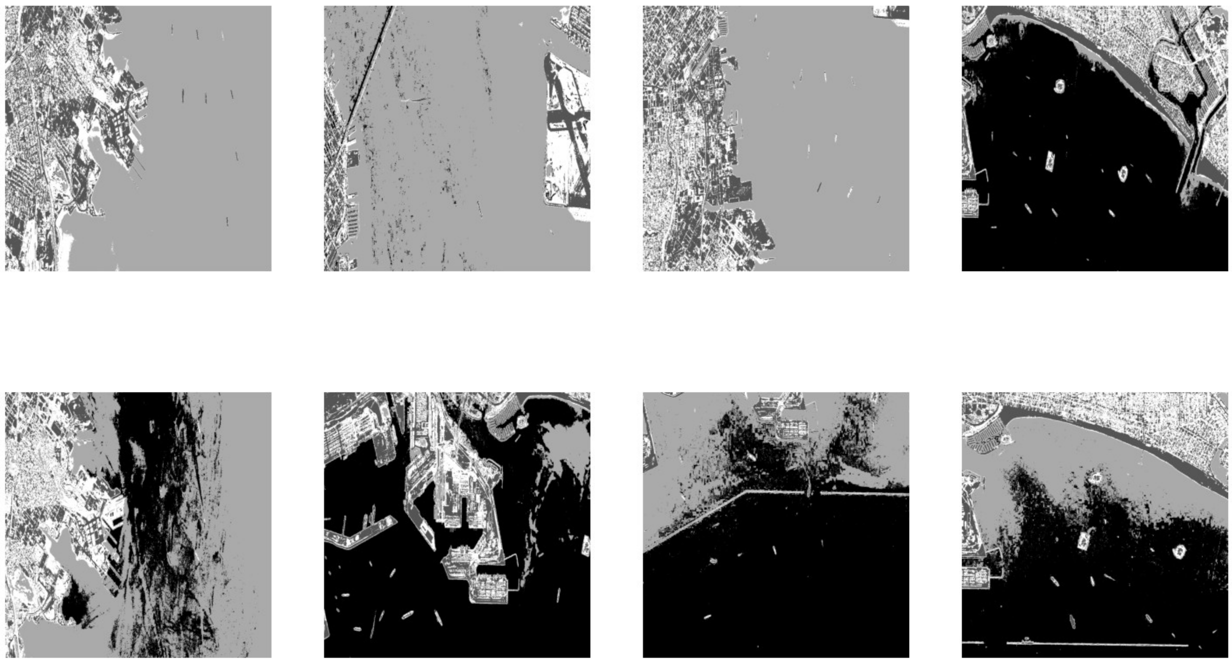
```
plot_images(preds[3].reshape((8,1000,1000)), title="KMeans with 3
Clusters", cmap='gray')
```

KMeans with 3 Clusters



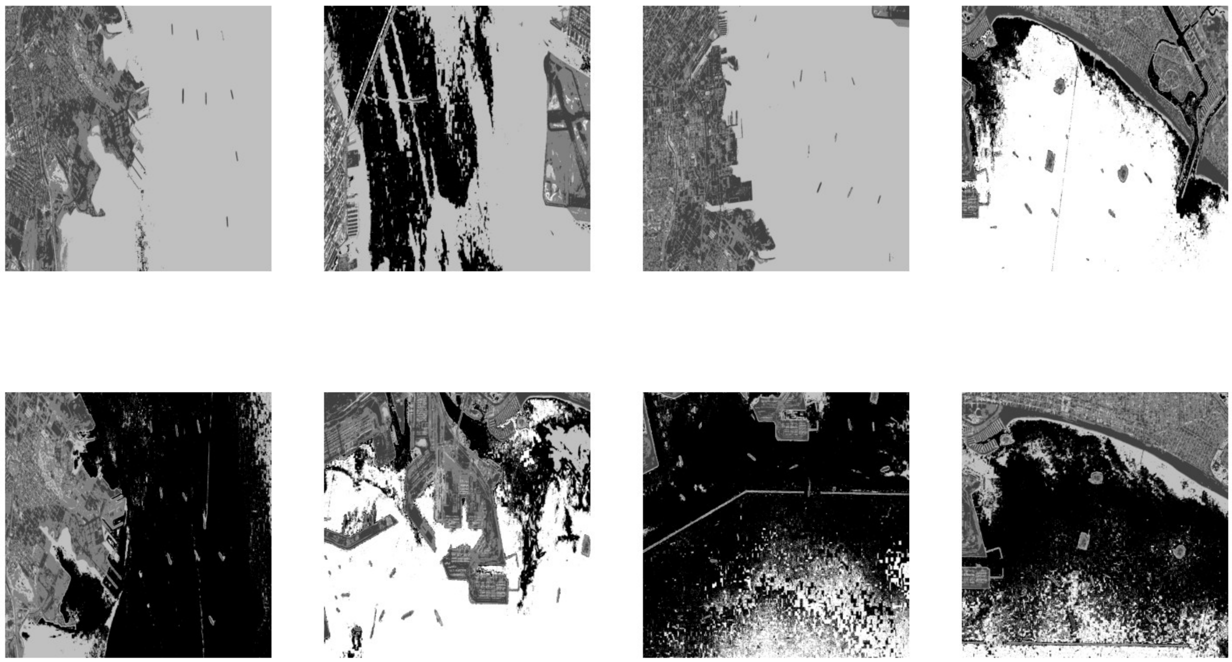
```
plot_images(preds[4].reshape((8,1000,1000)), title="KMeans with 4
Clusters", cmap='gray')
```

KMeans with 4 Clusters



```
plot_images(preds[5].reshape((8,1000,1000)), title="KMeans with 5 Clusters", cmap='gray')
```

KMeans with 5 Clusters

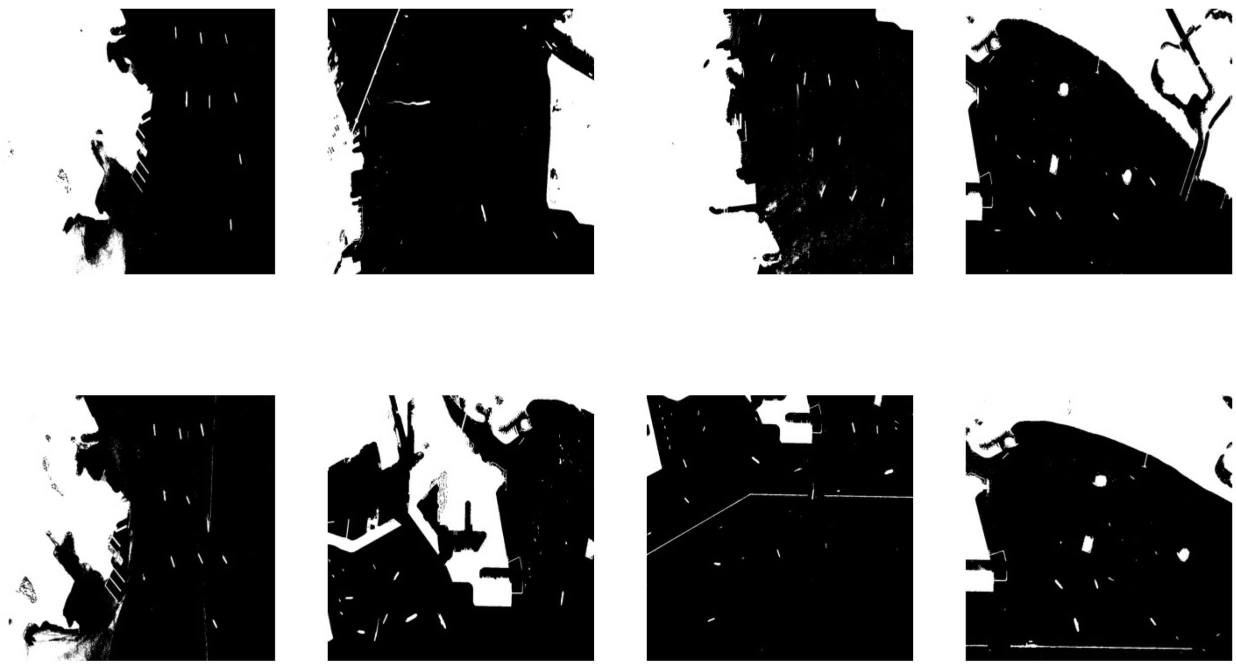


```
feature_maps = np.array(feature_maps)
cluster2 = preds[2].reshape((8,1000,1000))
blur_maps = [cv.blur(fmap, (25,25)).astype(np.int64) for fmap in
cluster2]
plot_images(blur_maps, title="Blur Maps", cmap="gray")
```

Blur Maps

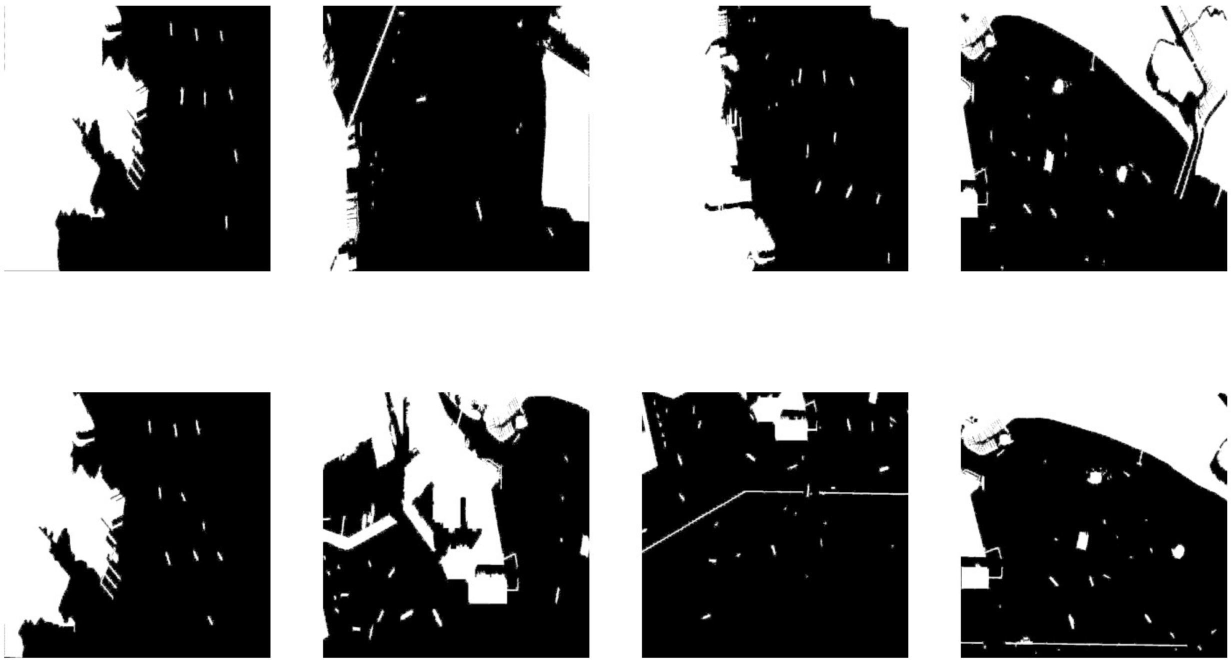
```
final_maps = np.maximum(feature_maps, blur_maps)
plot_images(final_maps, title="Final Predictions", cmap="gray")
```

Final Predictions



```
targets = load_images("/content/Masks", gray=True)
targets = [(target.astype(np.int64) > 1).astype(np.int64) for target
in targets]
plot_images(targets, title="Ground Truths", cmap='gray')
```

Ground Truths



```
from sklearn.metrics import precision_score, recall_score,
accuracy_score

for idx, (pred, truth) in enumerate(zip(final_maps, targets)):
  print(f"Image {idx+1} Scores:")
  print(f"Precision: {precision_score(truth, pred, average='micro')}\t
Recall: {recall_score(truth, pred, average='micro')}")

Image 1 Scores:
Precision: 0.907109507948744      Recall: 0.9826370561774739
Image 2 Scores:
Precision: 0.9903656714802226     Recall: 0.9121162876484252
Image 3 Scores:
Precision: 0.984941538363287      Recall: 0.9800828776826023
Image 4 Scores:
Precision: 0.9743328118268598     Recall: 0.9315600069372182
Image 5 Scores:
Precision: 0.9178759490063394     Recall: 0.9578681993609163
Image 6 Scores:
Precision: 0.9910150738843098     Recall: 0.9220914241345503
Image 7 Scores:
Precision: 0.9925112694488876     Recall: 0.7790629101908041
Image 8 Scores:
Precision: 0.9905091239287003     Recall: 0.956658243663726
```