Assignment1

October 6, 2023

[ ]:
```
# IMPORT ALL DEPENDENCIES

import os
import cv2
from matplotlib import pyplot as plt
import xml.etree.ElementTree as ET
from PIL import Image
import numpy as np
import math
from scipy.spatial import distance as distance_module
from scipy.spatial.distance import cityblock
```

[ ]:
```
# DECLARING ALL PATHS AND VARIABLES.

DATA_DIR = "\\".join(os.getcwd().split("\\")[:-1]) + "\\" + "DataSet"
ANNOTATIONS_DIR = DATA_DIR + "\\" + "Annotations\\"
IMG_DIR = DATA_DIR + "\\" + "Images\\"
PROCESSESED_PATH = DATA_DIR + '\\' + 'ProcessedDatasets\\'
AVAILABLE_CLASSES = ['n02089078-black-and-tan_coonhound','n02091831-Saluki'
                     ,'n02092002-Scottish_deerhound',
                     'n02095314-wire-haired_fox_terrier']


CLASS_NAMES = []
CLASS_CODES = []
ANNOTATION_PATHS = []
IMAGE_PATHS = []
PROCESSED_IMAGE_PATHS = []


for i in range(4):
    CLASS_NAMES.append("-".join(AVAILABLE_CLASSES[i].split("-")[1:]))
    CLASS_CODES.append(AVAILABLE_CLASSES[i].split("-")[0])
    ANNOTATION_PATHS.append(ANNOTATIONS_DIR + AVAILABLE_CLASSES[i] + "\\" )
    IMAGE_PATHS.append(IMG_DIR + AVAILABLE_CLASSES[i] + "\\")
    PROCESSED_IMAGE_PATHS.append(PROCESSESED_PATH + CLASS_CODES[i]+"-"␣
↪+CLASS_NAMES[i]+ "\\")
```

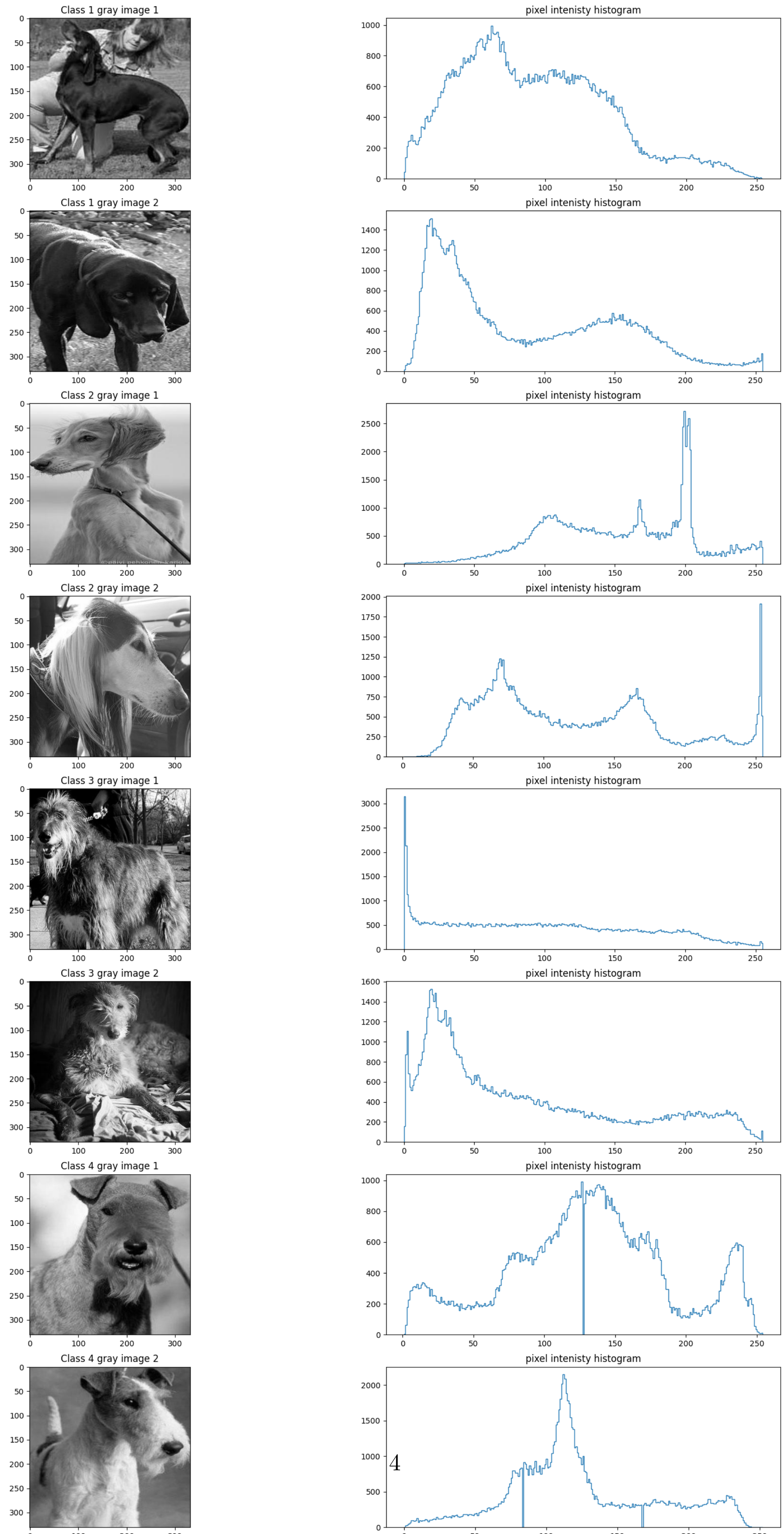
[ ]:
```python
# FUNCTION TO PROCESS THE IMAGE BASED ON THE CORRESPONDING ANNOTATIONS.

def get_bounding_boxes(annot):
  xml = annot
  tree = ET.parse(xml)
  root = tree.getroot()
  objects = root.findall('object')
  bbox = []
  for o in objects:
    bndbox = o.find('bndbox')
    xmin = int(bndbox.find('xmin').text)
    ymin = int(bndbox.find('ymin').text)
    xmax = int(bndbox.find('xmax').text)
    ymax = int(bndbox.find('ymax').text)
    bbox.append((xmin,ymin,xmax,ymax))
  return bbox

#FUNCTION TO CROP EVERY IMAGE IN EVERY CLASS AND SAVE IN A PROCESSED DIRECTORY.

def crop_image(image_path , annotation_path,save_path):
  img = cv2.imread(image_path,cv2.IMREAD_COLOR)
  img = cv2.cvtColor(img,cv2.COLOR_BGR2RGB)
  bb = get_bounding_boxes(annotation_path)
  bbox = bb[0]
  cropped_data = img[bbox[1]:bbox[3], bbox[0]:bbox[2]]    # cropping the image
  cropped_data = cv2.resize(cropped_data,dsize=(331 ,331)) # rescaling it to a␣
↪square image
  crop_img = Image.fromarray(cropped_data,'RGB')  # converting the numpy array␣
↪to an image
  crop_img.save(save_path)
```

[ ]:
```python
for i in range(4):
    for dog in os.listdir(IMAGE_PATHS[i]):
        image_path = dog
        annotation_path = dog.split(".")[0]
        if not os.path.exists(PROCESSED_IMAGE_PATHS[i]):
            os.mkdir(PROCESSED_IMAGE_PATHS[i])
        crop_image(IMAGE_PATHS[i]+  image_path, ANNOTATION_PATHS[i]
                     + annotation_path, PROCESSED_IMAGE_PATHS[i] + dog)
```

(b)Plotting Grayscaled images and their corresponding intensity equalized histogram

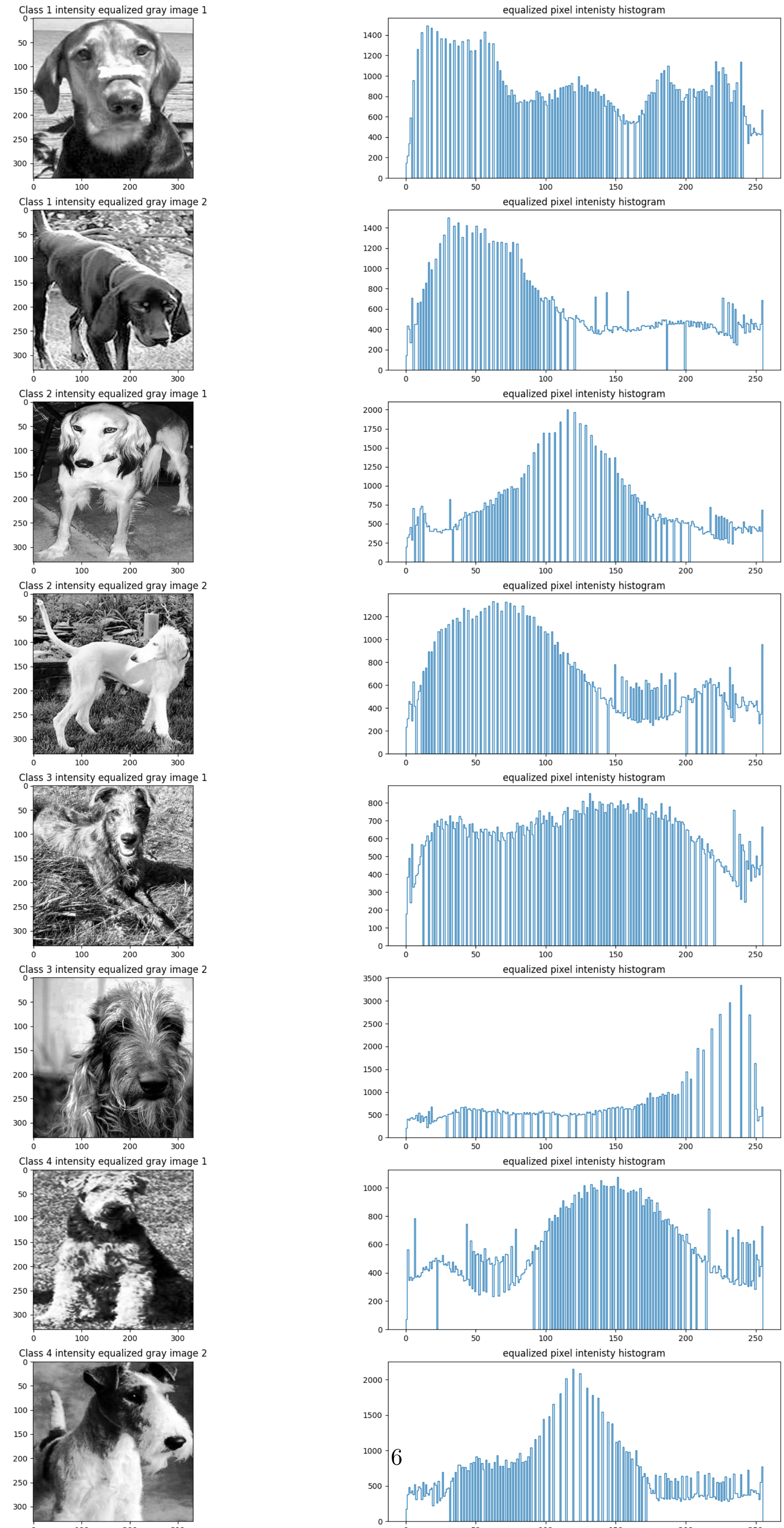
(i & ii) plotting grayscaled images and pixel intensity histograms.

[ ]:
```
fig = plt.figure(figsize=(20, 35))
rows = 8
columns = 2

for i in range(4):
    img1 = cv2.imread(PROCESSED_IMAGE_PATHS[i]
                      +  os.listdir(PROCESSED_IMAGE_PATHS[i])[np.random.
 ↪randint(0,40)] )
    img2 = cv2.imread(PROCESSED_IMAGE_PATHS[i]
                      +  os.listdir(PROCESSED_IMAGE_PATHS[i])[np.random.
 ↪randint(0,40)] )
    img1_gray = cv2.cvtColor(img1,cv2.COLOR_BGR2GRAY)
    img2_gray = cv2.cvtColor(img2,cv2.COLOR_BGR2GRAY)
    arr_1 =img1_gray.flatten()
    arr_2 =img2_gray.flatten()

    fig.add_subplot(rows,columns,4*i+1)
    plt.imshow(img1_gray,cmap='gray')
    plt.title("Class "+str(i+1)+" gray image 1")


    fig.add_subplot(rows,columns,2*(2*i+1))
    plt.hist(arr_1,bins=255,histtype='step')
    plt.title("pixel intenisty histogram")

    fig.add_subplot(rows,columns,4*i+3)
    plt.imshow(img2_gray,cmap='gray')
    plt.title("Class "+str(i+1)+" gray image 2")

    fig.add_subplot(rows,columns,2*(2*i+2))
    plt.hist(arr_2,bins=255,histtype='step')
    plt.title("pixel intenisty histogram")
```


Class 1 gray image 1
pixel intenisty histogram
Class 1 gray image 2
pixel intenisty histogram
Class 2 gray image 1
pixel intenisty histogram
Class 2 gray image 2
pixel intenisty histogram
Class 3 gray image 1
pixel intenisty histogram
Class 3 gray image 2
pixel intenisty histogram
Class 4 gray image 1
pixel intenisty histogram
Class 4 gray image 2
pixel intenisty histogram

(iii) plotting intensity equalized grayscale images and corresponding pixel intensity histograms.

[ ]:
```
fig = plt.figure(figsize=(20, 35))

rows = 8
columns = 2


for i in range(4):

    img1 = cv2.imread(PROCESSED_IMAGE_PATHS[i]
                      +  os.listdir(PROCESSED_IMAGE_PATHS[i])[np.random.
 ↪randint(0,40)] )
    img2 = cv2.imread(PROCESSED_IMAGE_PATHS[i]
                      +  os.listdir(PROCESSED_IMAGE_PATHS[i])[np.random.
 ↪randint(0,40)] )
    img1_gray = cv2.cvtColor(img1,cv2.COLOR_BGR2GRAY)
    img2_gray = cv2.cvtColor(img2,cv2.COLOR_BGR2GRAY)


    img1_eq = cv2.equalizeHist(img1_gray)
    img2_eq = cv2.equalizeHist(img2_gray)
    arr_1_eq =img1_eq.flatten()
    arr_2_eq =img2_eq.flatten()

    fig.add_subplot(rows,columns,4*i+1)
    plt.imshow(img1_eq,cmap='gray')
    plt.title("Class "+str(i+1)+" intensity equalized gray image 1")

    fig.add_subplot(rows,columns,2*(2*i+1))
    plt.hist(arr_1_eq,bins=255,histtype='step')
    plt.title("equalized pixel intenisty histogram")

    fig.add_subplot(rows,columns,4*i+3)
    plt.imshow(img2_eq,cmap='gray')
    plt.title("Class "+str(i+1)+" intensity equalized gray image 2")

    fig.add_subplot(rows,columns,4*(i+1))
    plt.hist(arr_2_eq,bins=255,histtype='step')
    plt.title("equalized pixel intenisty histogram")
```

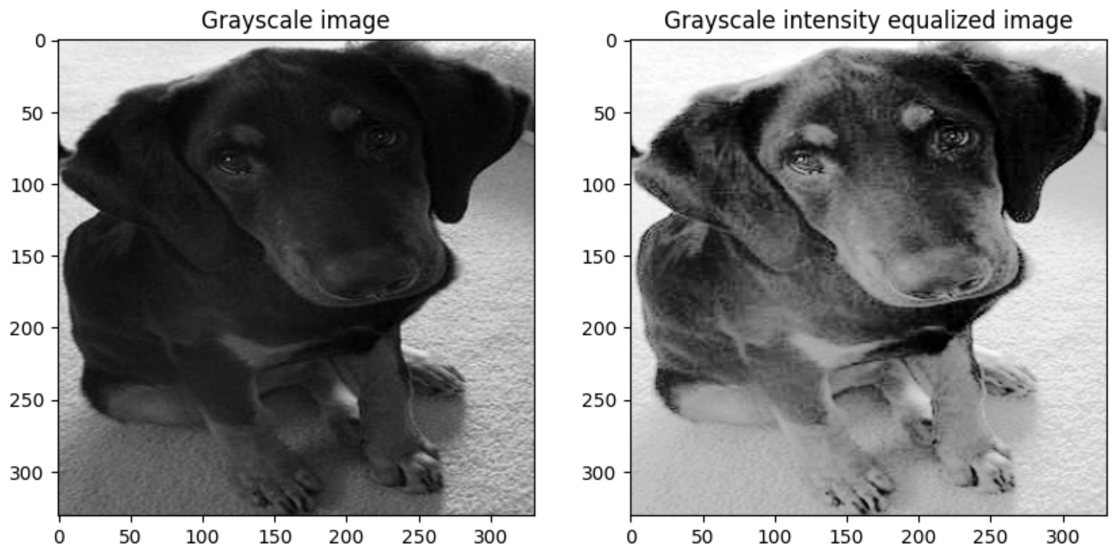


Class 1 intensity equalized gray image 1
equalized pixel intenisty histogram
Class 1 intensity equalized gray image 2
equalized pixel intenisty histogram
Class 2 intensity equalized gray image 1
equalized pixel intenisty histogram
Class 2 intensity equalized gray image 2
equalized pixel intenisty histogram
Class 3 intensity equalized gray image 1
equalized pixel intenisty histogram
Class 3 intensity equalized gray image 2
equalized pixel intenisty histogram
Class 4 intensity equalized gray image 1
equalized pixel intenisty histogram
Class 4 intensity equalized gray image 2
equalized pixel intenisty histogram

(iv)Comapring gray scaled image and intensity equalized image.

[ ]:
```
fig = plt.figure(figsize=(10,5))
rows = 1
cols = 2

img = cv2.imread(PROCESSED_IMAGE_PATHS[0]
                      +  os.listdir(PROCESSED_IMAGE_PATHS[0])[np.random.
 ↪randint(0,40)])

img_gray = cv2.cvtColor(img,cv2.COLOR_BGR2GRAY)
img_eq = cv2.equalizeHist(img_gray)

fig.add_subplot(rows,cols,1)
plt.imshow(img_gray,cmap='gray')
plt.title("Grayscale image")

fig.add_subplot(rows,cols,2)
plt.imshow(img_eq,cmap='gray')
plt.title("Grayscale intensity equalized image")
```

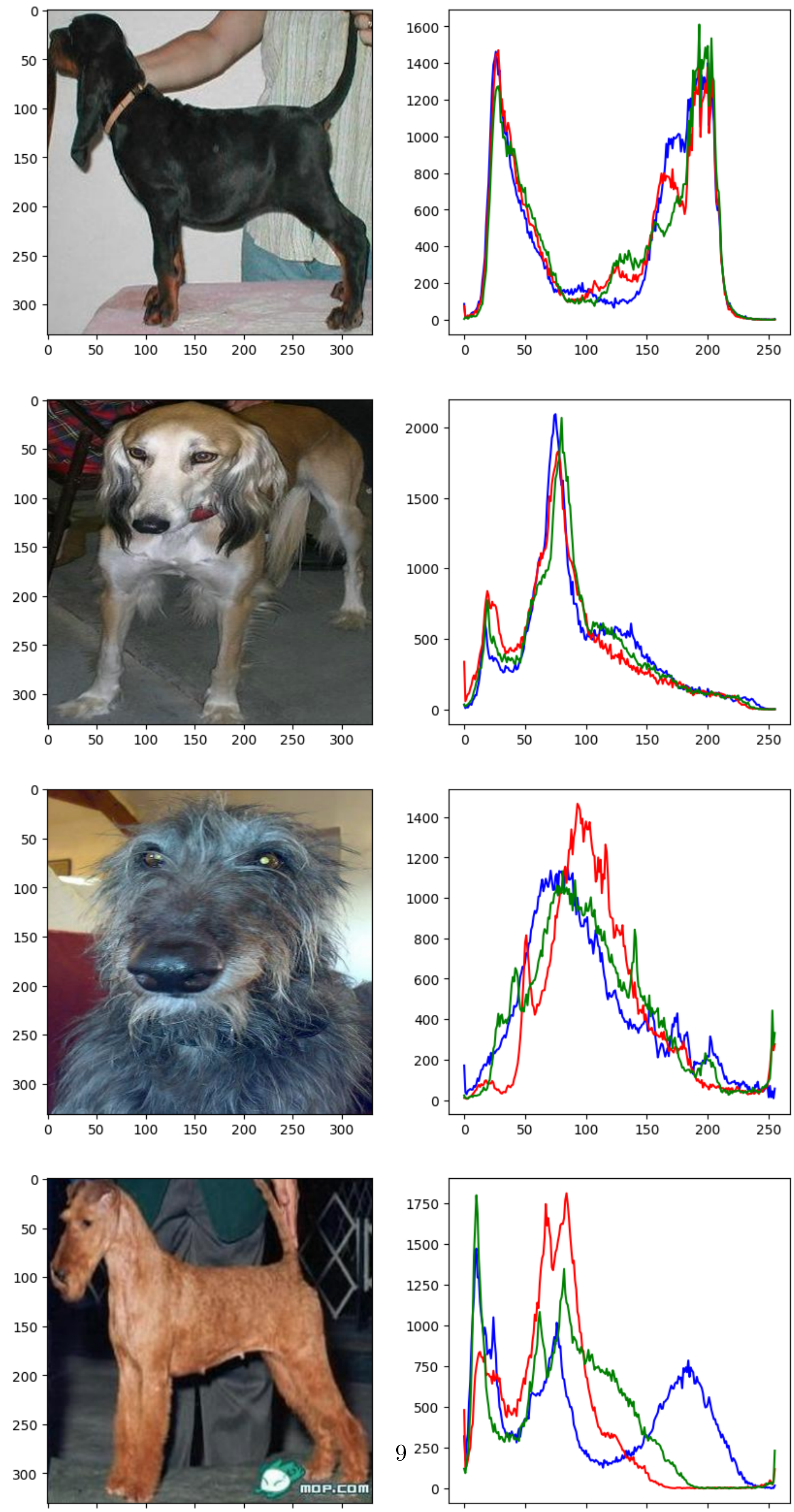
[ ]:
```
Text(0.5, 1.0, 'Grayscale intensity equalized image')
```




```
Observation:
The intensity equalized image is a bit brighter than the gray scale image. The contrast is muc
```

(c) RGB Histogram

[ ]:
```
fig = plt.figure(figsize=(10, 20))

rows = 4
columns = 2


for i in range(4):

    img = cv2.imread(PROCESSED_IMAGE_PATHS[i] +  os.
 ↪listdir(PROCESSED_IMAGE_PATHS[i])[7] ,cv2.IMREAD_COLOR)
    fig.add_subplot(rows,columns,2*(i)+1)
    plt.imshow(img)
    img_hist_blue = cv2.calcHist([img],[0],None,[256],[0,256])
    img_hist_red = cv2.calcHist([img],[2],None,[256],[0,256])
    img_hist_green = cv2.calcHist([img],[1],None,[256],[0,256])


    fig.add_subplot(rows,columns,2*(i+1))
    plt.plot(img_hist_blue,color='blue')
    plt.plot(img_hist_red,color='red')
    plt.plot(img_hist_green,color='green')
```

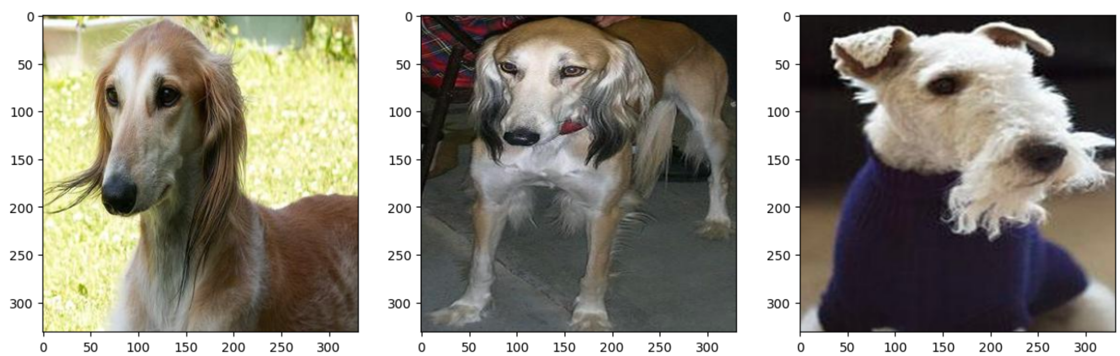

0 50 100 150 200 250 300
0 50 100 150 200 250 300
0 200 400 600 800 1000 1200 1400 1600
0 50 100 150 200 250
0 50 100 150 200 250 300
0 50 100 150 200 250 300
0 500 1000 1500 2000
0 50 100 150 200 250
0 50 100 150 200 250 300
0 50 100 150 200 250 300
0 200 400 600 800 1000 1200 1400
0 50 100 150 200 250
0 50 100 150 200 250 300
0 50 100 150 200 250 300
0 250 500 750 1000 1250 1500 1750
0 50 100 150 200 250
mop.com

(d)Histogram Comparison

(i) picking 3 images 2 from same class and 1 from a different class

[ ]:
```
class_1 = 1
class_2 = 3
img1 = 4
img2= 7
img3 = 10


img1_class_1 = cv2.imread(PROCESSED_IMAGE_PATHS[class_1]
                          + os.listdir(PROCESSED_IMAGE_PATHS[class_1])[img1] )
img2_class_1 = cv2.imread(PROCESSED_IMAGE_PATHS[class_1]
                          + os.listdir(PROCESSED_IMAGE_PATHS[class_1])[img2] )
img3_class_2 = cv2.imread(PROCESSED_IMAGE_PATHS[class_2]
                          + os.listdir(PROCESSED_IMAGE_PATHS[class_2])[img3] )

fig = plt.figure(figsize=(15, 5))
fig.add_subplot(1,3,1)
plt.imshow(img1_class_1)
fig.add_subplot(1,3,2)
plt.imshow(img2_class_1)
fig.add_subplot(1,3,3)
plt.imshow(img3_class_2)
```

[ ]: <matplotlib.image.AxesImage at 0x1a730fe9410>



(ii) converting to grayscale pixel intensity histograms.

[ ]:
```
img1_gray_class_1 = cv2.cvtColor(img1_class_1,cv2.COLOR_BGR2GRAY)
img2_gray_class_1 = cv2.cvtColor(img2_class_1,cv2.COLOR_BGR2GRAY)
img3_gray_class_2 = cv2.cvtColor(img3_class_2,cv2.COLOR_BGR2GRAY)
```

```
img1_eq = cv2.equalizeHist(img1_gray_class_1)
img2_eq = cv2.equalizeHist(img2_gray_class_1)
img3_eq = cv2.equalizeHist(img3_gray_class_2)

hist1 = cv2.calcHist([img1_eq], [0], None, [256], [0, 256])
hist2 = cv2.calcHist([img2_eq], [0], None, [256], [0, 256])
hist3 = cv2.calcHist([img3_eq], [0], None, [256], [0, 256])


arr1= []
for i in hist1:
    arr1.append(i[0])

arr2= []
for i in hist2:
    arr2.append(i[0])

arr3= []
for i in hist3:
    arr3.append(i[0])
```

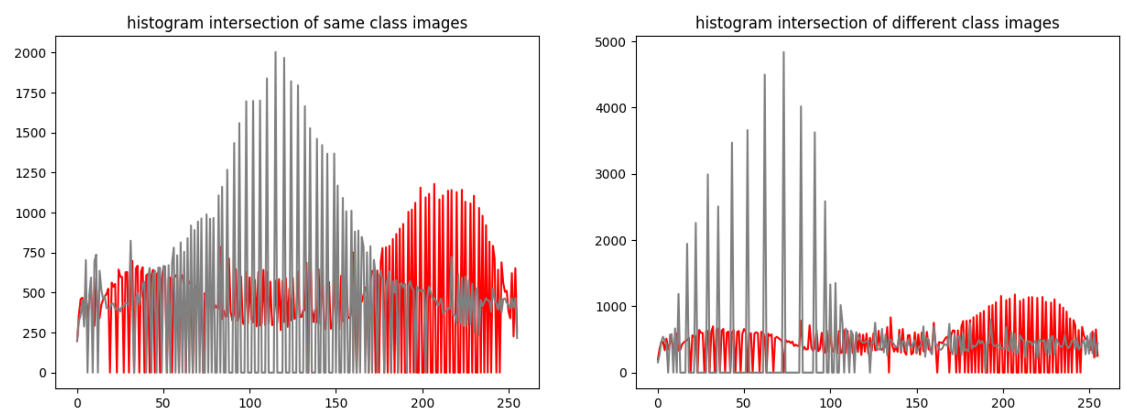
(iii) Histogram comparision using different metrics.

```
[ ]: # Euclidean Distance
print('euclidean distance of same class images:',distance_module.
 ↪euclidean(arr1, arr2))
print('euclidean distance of different class images:',distance_module.
 ↪euclidean(arr1, arr3))



print('manhattan distance of same class images:',cityblock(arr1,arr2))
print('manhattan distance of different class images:',cityblock(arr1,arr3))




print('bhattacharya distance of same class images:',cv2.
 ↪compareHist(hist1,hist2,cv2.HISTCMP_BHATTACHARYYA))
print('bhattacharya distance of different class images:',cv2.
 ↪compareHist(hist1,hist3,cv2.HISTCMP_BHATTACHARYYA))

fig = plt.figure(figsize=(15, 5))

rows = 1
columns = 2
print('Histogram Intersection of same class images:',cv2.
 ↪compareHist(hist1,hist2,cv2.HISTCMP_INTERSECT))
```

```
print('Histogram Intersection of different class images:',cv2.
 ↪compareHist(hist1,hist3,cv2.HISTCMP_INTERSECT))

fig.add_subplot(rows,columns,1)
plt.plot(hist1,color = 'red')
plt.plot(hist2,color = 'grey')
plt.title('histogram intersection of same class images')

fig.add_subplot(rows,columns,2)
plt.plot(hist1,color = 'red')
plt.plot(hist3,color = 'grey')
plt.title('histogram intersection of different class images')
```

```
euclidean distance of same class images: 8293.88671875
euclidean distance of different class images: 12044.4248046875
manhattan distance of same class images: 108768.0
manhattan distance of different class images: 119144.0
bhattacharya distance of same class images: 0.5702275273158051
bhattacharya distance of different class images: 0.6055652697725089
Histogram Intersection of same class images: 55177.0
Histogram Intersection of different class images: 49989.0
```

[ ]: `Text(0.5, 1.0, 'histogram intersection of different class images')`



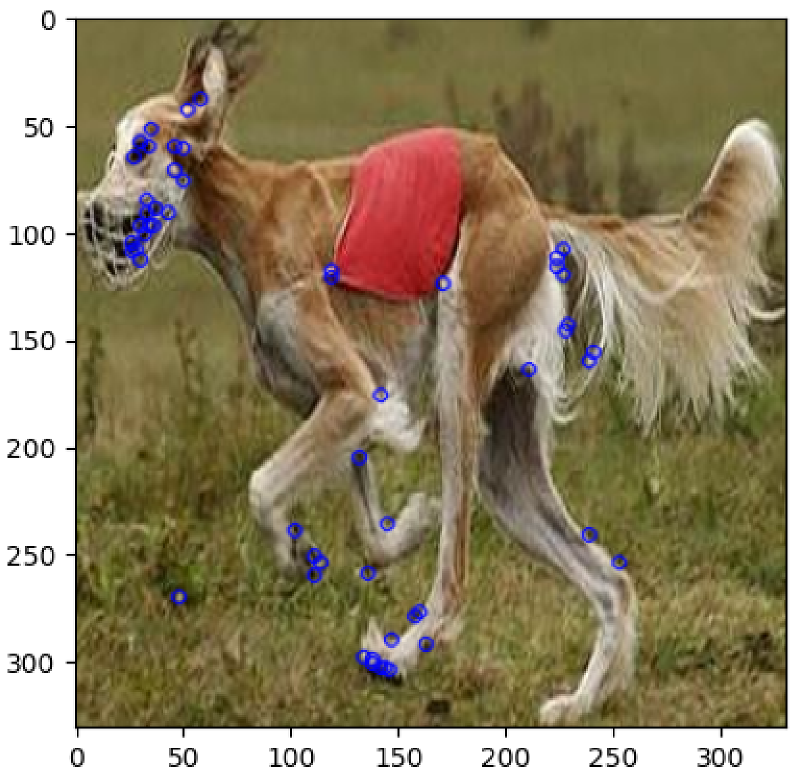
observation:

The distances are higher in case of two images from different classes regardless the metric used, Except the histogram intersect metric as this metric shows how much similarity is between the two histograms Hence this metric will be much higher for same class objects.

(e) Image Feature Descriptor: ORB (Oriented FAST and Rotated BRIEF)

[ ]:
```
edge_threshold = 25
patch_size = 20
```

```
keypoints = 55

img = cv2.imread(PROCESSED_IMAGE_PATHS[class_1] +
                 os.listdir(PROCESSED_IMAGE_PATHS[class_1])[88] )
orb = cv2.ORB_create(edgeThreshold= edge_threshold,
                     patchSize=patch_size, nlevels=1,
                     fastThreshold=20,scaleFactor=2,
                     WTA_K=4,scoreType=cv2.ORB_HARRIS_SCORE
                     ,firstLevel=0, nfeatures=keypoints)

kp = orb.detect(img,None)

kp, des = orb.compute(img, kp)

img2 = cv2.drawKeypoints(img, kp, None, color=(0,0,255), flags=0)
plt.imshow(img2), plt.show()
```




```
[ ]: (<matplotlib.image.AxesImage at 0x1a730ff5950>, None)
```

Question: edge threshold used is 25, patch size used is 20 and keypoints extracted are 55

(f) PCA dimensionality reduction

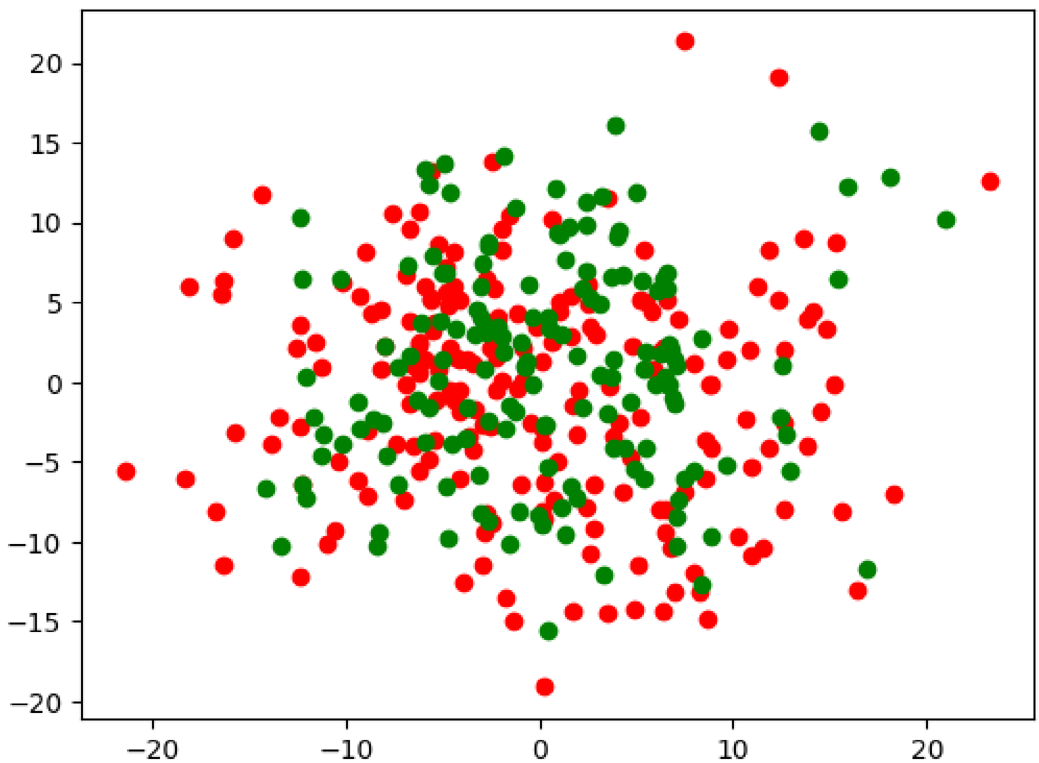
[ ]:
```
dataset = []


# converting all the images into a single dataset.

for dog in os.listdir(PROCESSED_IMAGE_PATHS[1]):
    img1_eq = cv2.imread(PROCESSED_IMAGE_PATHS[1] + dog,cv2.IMREAD_GRAYSCALE)
    hist1 = cv2.calcHist([img1_eq], [0], None, [256], [0, 256])
    dataset.append(hist1)

c1 = len(dataset)

for dog in os.listdir(PROCESSED_IMAGE_PATHS[3]):
    img2_eq = cv2.imread(PROCESSED_IMAGE_PATHS[3] + dog,cv2.IMREAD_GRAYSCALE)
    hist2 = cv2.calcHist([img2_eq], [0], None, [256], [0, 256])

    dataset.append(hist2)

dataset = np.array(dataset)[:,:,0]

final_dataset = dataset
```

[ ]:
```
from sklearn.decomposition import PCA
from sklearn.preprocessing import StandardScaler

data = StandardScaler().fit_transform(final_dataset)
print(data.shape)
pca= PCA(n_components=2)
principalComponents_dog = pca.fit_transform(data)

principalComponents_dog.shape
```

```
(357, 256)
```

[ ]:
```
(357, 2)
```

[ ]:
```
fig = plt.figure()
ax1 = fig.add_subplot(111)

plt.scatter(principalComponents_dog[:c1,0],principalComponents_dog[:c1,1],c='r')
plt.scatter(principalComponents_dog[c1:,0],principalComponents_dog[c1:,1],c='g')
plt.show()
```



[ ]:
```
dataset = []



# converting all the images into a single dataset.

for dog in os.listdir(PROCESSED_IMAGE_PATHS[1]):
    img1_eq = cv2.imread(PROCESSED_IMAGE_PATHS[1] + dog,cv2.IMREAD_GRAYSCALE)
    hist1 = cv2.calcHist([img1_eq], [0], None, [256], [0, 256])
    dataset.append(hist1)

c1 = len(dataset)

for dog in os.listdir(PROCESSED_IMAGE_PATHS[3]):
    img2_eq = cv2.imread(PROCESSED_IMAGE_PATHS[3] + dog,cv2.IMREAD_GRAYSCALE)
    hist2 = cv2.calcHist([img2_eq], [0], None, [256], [0, 256])

    dataset.append(hist2)

dataset = np.array(dataset)[:,:,0]

final_dataset = dataset.transpose()
final_dataset.shape
```

[ ]: (256, 357)

[ ]:
```
from sklearn.decomposition import PCA
from sklearn.preprocessing import StandardScaler

data = StandardScaler().fit_transform(final_dataset)
print(data.shape)
pca= PCA(n_components=2)
principalComponents_dog = pca.fit_transform(data)

principalComponents_dog.shape

fig = plt.figure()
ax1 = fig.add_subplot(111)

arr = np.linspace(0, 255, num=256)
plt.scatter(arr,principalComponents_dog[:,0],c='r')
plt.scatter(arr,principalComponents_dog[:,1],c='g')
plt.show()
```

(256, 357)