```
========================================
Bella Falbo_899793_assignsubmission_file_/
========================================
List of submitted files:
Bella Falbo.pdf
HW5.py
Untitled.ipynb
extension.txt
feedback
hamilton.jpg
robeson.jpg
========================================
File:  ../../../hw/hw5_rubric.txt
========================================
CSC 268:  Image Processing Fundamentals
Homework 5 Rubric

____ 1 pt: Explicitly identifies sources & consultations (even if none).
           Partner is clearly specified if peer programming.

____ 2 pts: integral image function

____ 2 pts: single-scale f1 value function

____ 2 pts: single-scale f2 value function

____ 4 pts: single-scale face detection function

____ 1 pts: single-scale function tested on images resized by different amounts

____ 1 pt: any scale rectangle-sum function

0.5
____ 1 pt: any scale f1 value function

0.5
____ 1 pt: any scale f2 value function

0.5
____ 1 pt: any scale face detection function

0.5
____ 1 pt: all scale face detection function

0.5
____ 1 pt: tested detection on multiple images

____ 2 pts: reflection included

     ____ 1 pt: reflects on learning goals of the assignment and whether they have been met

     ____ 1 pt: discusses choices made & reasoning behind them


       17.5
Total: ____/20
```

```
========================================

========================================
extension.txt
========================================
Bella Falbo
HW5 originally due APR11
four day extension, now due APR15
accomodations give extension day exception as discussed.
(a longer extension is taken for this assignment due to covid and I wanted to be able to ask
 questions)
========================================
HW5.py
========================================
import cv2 as cv
import numpy as np
from scipy.ndimage import label
from scipy.spatial import distance_matrix
import matplotlib.pyplot as plt
import matplotlib as mpl
from math import ceil

mpl.rc('image', cmap='gray')

def imshow(img,cmap=None):
    plt.imshow(img)
    plt.axis('off')
    if cmap:
        plt.set_cmap(cmap)
    plt.show()

robeson = cv.imread('robeson.jpg',0).astype(np.float32)/255.0
imshow(robeson)

#create integral image
def integral_image(img):
    return np.cumsum(np.cumsum(img, axis=0), axis=1)
iir = integral_image(robeson)

# return the f1 values for any image.
def f1_values(img,integral):
    r_4x12 = integral[4:,12:]+integral[:-4,:-12]-integral[4:,:-12]-integral[:-4,12:]
    f1 = r_4x12[:-4,:]-r_4x12[4:,:]
    f1pad = np.pad(f1,((4,4),(6,6)))
    plt.figure
    plt.imshow(img)
    y,x = np.nonzero(f1pad>20)#;
    plt.plot(x,y,'r.')#;
    plt.axis('off')
    plt.show()
    return (f1pad)

f1values= f1_values(robeson,iir)

def f2_values(img, integral):
    r_4x4 = integral[4:,4:]+integral[:-4,:-4]-integral[:-4,4:]-integral[4:,:-4]
    f2= 2*r_4x4[:,4:-4]-r_4x4[:,:-8]-r_4x4[:,8:]
    f2pad=np.pad (f2,((2,2),(6,6)))
    plt.figure
    plt.imshow(img)
    y,x = np.nonzero(f2pad>20)#;
    plt.plot(x,y,'r.')#;
    plt.axis('off')
```

```
    plt.show()
    return (f2pad)

f2values=f2_values(robeson,iir)

def showFaces(img,x,y):
    '''Draws approximate boxes around detected face points.'''
    plt.figure
    plt.imshow(robeson)
    ax = plt.gca()
    for i in range(len(y)):
        r = mpl.patches.Rectangle((x[i]-12,y[i]-12),24,36,edgecolor='r',fill=False)
        ax.add_patch(r)
    #plt.plot(x,y,'c.')#;
    plt.axis('off')
    plt.show()

# assumes you have already defined f1p and f2p above.
y,x = np.nonzero(np.logical_and(f1values>20,np.roll(f2values,-4,0)>16))#;
showFaces(robeson,x,y)

# TODO: write a single function that takes an image and returns the y,x coordinates of the
# faces detected using the method above.  Call it on the image scaled by different amounts:
# 1.25, 0.8, 0.64, etc. (use cv.resize).
def face_coord(img,resizeamt):
    img=cv.resize(img,None,fx=resizeamt,fy=resizeamt)
    integralimg= integral_image(img)
    f1value=f1_values(img,integralimg)
    f2value=f2_values(img,integralimg)
    y,x=np.nonzero(np.logical_and(f1value>20,np.roll(f2value,-4,0)>16))
    showFaces(img,x,y)
    return np.dstack([x,y])
```

Thresholds should be made into parameters.

```
print(face_coord(robeson, .64))
print(face_coord(robeson, .8))
print(face_coord(robeson, 1.25))
print(face_coord(robeson, 1.75))

#TODO: To complete the detection system, we therefore need to do a few things:

#Write a general rectangle-sum function that can compute the sums for rectangles of any size
def sum_any_size(img,xdim,ydim):
    integral=integral_image(img)
    block=integral[xdim:,ydim:]+integral[:-xdim,:-ydim]-integral[xdim:,:-ydim]-integral[:-xd
im,ydim:]
    return(block)

#Write functions that can compute the f1 and f2 filters, given a scale. For example, at scal
e
# 1.25 the f1 filter will use 5x15 boxes and the f2 filter will use 5x5 boxes.
def filters_scale(img, scale):
    f1xdim=int(4*scale)
    f1ydim=int(12*scale)
    f2dims=int(4*scale)
    block1=sum_any_size(img,f1xdim,f1ydim)
    f1 = block1[:-4,:]-block1[4:,:]
```

< the 4 here needs to scale also

```
    block2=sum_any_size(img,f2dims,f2dims)
    f2= 2*block2[:,4:-4]-block2[:,:-8]-block2[:,8:]
```

< as do 4 and 8 here

```
    f1xpad= ceil((img.shape[0]-f1.shape[0])/2)
    f2xpad= ceil((img.shape[0]-f2.shape[0])/2)
    f1ypad= ceil((img.shape[1]-f1.shape[1])/2)
    f2ypad= ceil((img.shape[1]-f2.shape[1])/2)
    f1pad = np.pad(f1,((f1xpad,f1xpad),(f1ypad,f1ypad)))
    f2pad= np.pad(f2,((f2xpad,f2xpad),(f2ypad,f2ypad)))
    return f1pad, f2pad
f1v,f2v= filters_scale(robeson,1.25)

#Use the filter computations in a function that takes an image plus scale as input, and retu
rns
# the y and x for all faces detected at that scale
def face_cord_scale(img, scale):
```

Thresholds should be *scale^2

```
    f1val,f2val= filters_scale(img,scale)
    y,x = np.nonzero(np.logical_and(f1val>(20*scale),np.roll(f2val,-4,0)>(16*scale)))
    return np.dstack([x,y])

#Write one more function that will call the one above in a loop, at different scales separat
ed
# by multiples of 1.25. It should return the scale and coordinates for each detection.
def face_loops(img):
```

Start at 0.8

```
    scale=1.25
    while scale <=10:
        print("coordinates for faces at scale " + str(scale))
        f1v,f2v= filters_scale(robeson, scale)
        y,x = np.nonzero(np.logical_and(f1v>(20),np.roll(f2v,-4,0)>(16)))
        showFaces(img,x,y)
        print(face_cord_scale(img,scale))
        scale=scale+1.25
```

Multiply by 1.25

```
face_loops(robeson)

#reflection
# I found this project really interesting, but i definitely see the pitfalls of doing face d
etection this way.
#By trying other iamges, the detector hardly ever picted up on faces that were not white and
 that is unsettling
# because i never really thought of these programs as being able to be racist in that sense
and that was a really
#itnersting fact to come out of this. I also noticed that there were many cases where sharp
contrast between black
# and white or dark shadows in pictures were picked as "faces" and im curious to see how to
fix that. It seems prety
# inconsistent and that's a tad bit annoying.


# I did not work with anyone. I used the Numpy documentation and scikit documentation along
with the resources you provided
========================================
```

I agree: the results here show some basic shortcomings to the algorithm. For the full Viola-Jones algorithm, this would be only the first step, and the thresholds would be deliberately set low so as to avoid ruling out any faces if at all possible.

In [ ]:
```
import cv2 as cv
import numpy as np
from scipy.ndimage import label
from scipy.spatial import distance_matrix
import matplotlib.pyplot as plt
import matplotlib as mpl
from math import ceil

mpl.rc('image', cmap='gray')

def imshow(img,cmap=None):
    plt.imshow(img)
    plt.axis('off')
    if cmap:
        plt.set_cmap(cmap)
    plt.show()

robeson = cv.imread('robeson.jpg',0).astype(np.float32)/255.0
imshow(robeson)

#create integral image
def integral_image(img):
    return np.cumsum(np.cumsum(img, axis=0), axis=1)
iir = integral_image(robeson)

# return the f1 values for any image.
def f1_values(img,integral):
    r_4x12 = integral[4:,12:]+integral[:-4,:-12]-integral[4:,:-12]-integral[:-4,12:]
    f1 = r_4x12[:-4,:]-r_4x12[4:,:]
    f1pad = np.pad(f1,((4,4),(6,6)))
    plt.figure
    plt.imshow(img)
    y,x = np.nonzero(f1pad>20)#;
    plt.plot(x,y,'r.')#;
    plt.axis('off')
    plt.show()
    return (f1pad)

f1values= f1_values(robeson,iir)

def f2_values(img, integral):
    r_4x4 = integral[4:,4:]+integral[:-4,:-4]-integral[:-4,4:]-integral[4:,:-4]
    f2= 2*r_4x4[:,4:-4]-r_4x4[:,:-8]-r_4x4[:,8:]
    f2pad=np.pad (f2,((2,2),(6,6)))
    plt.figure
    plt.imshow(img)
    y,x = np.nonzero(f2pad>20)#;
    plt.plot(x,y,'r.')#;
    plt.axis('off')
    plt.show()
    return (f2pad)

f2values=f2_values(robeson,iir)

def showFaces(img,x,y):
    '''Draws approximate boxes around detected face points.'''
    plt.figure
    plt.imshow(robeson)
```

```
    ax = plt.gca()
    for i in range(len(y)):
        r = mpl.patches.Rectangle((x[i]-12,y[i]-12),24,36,edgecolor='r',fill=False)
        ax.add_patch(r)
    #plt.plot(x,y,'c.')#;
    plt.axis('off')
    plt.show()

# assumes you have already defined f1p and f2p above.
y,x = np.nonzero(np.logical_and(f1values>20,np.roll(f2values,-4,0)>16))#;
showFaces(robeson,x,y)

# TODO: write a single function that takes an image and returns the y,x coordinates of
# faces detected using the method above.  Call it on the image scaled by different amo
# 1.25, 0.8, 0.64, etc. (use cv.resize).
def face_coord(img,resizeamt):
    img=cv.resize(img,None,fx=resizeamt,fy=resizeamt)
    integralimg= integral_image(img)
    f1value=f1_values(img,integralimg)
    f2value=f2_values(img,integralimg)
    y,x=np.nonzero(np.logical_and(f1value>20,np.roll(f2value,-4,0)>16))
    showFaces(img,x,y)
    return np.dstack([x,y])

print(face_coord(robeson, .64))
print(face_coord(robeson, .8))
print(face_coord(robeson, 1.25))
print(face_coord(robeson, 1.75))

#TODO: To complete the detection system, we therefore need to do a few things:

#Write a general rectangle-sum function that can compute the sums for rectangles of ar
def sum_any_size(img,xdim,ydim):
    integral=integral_image(img)
    block=integral[xdim:,ydim:]+integral[:-xdim,:-ydim]-integral[xdim:,:-ydim]-integra
    return(block)

#Write functions that can compute the f1 and f2 filters, given a scale. For example, a
# 1.25 the f1 filter will use 5x15 boxes and the f2 filter will use 5x5 boxes.
def filters_scale(img, scale):
    f1xdim=int(4*scale)
    f1ydim=int(12*scale)
    f2dims=int(4*scale)
    block1=sum_any_size(img,f1xdim,f1ydim)
    f1 = block1[:-4,:]-block1[4:,:]
    block2=sum_any_size(img,f2dims,f2dims)
    f2= 2*block2[:,4:-4]-block2[:,:-8]-block2[:,8:]
    f1xpad= ceil((img.shape[0]-f1.shape[0])/2)
    f2xpad= ceil((img.shape[0]-f2.shape[0])/2)
    f1ypad= ceil((img.shape[1]-f1.shape[1])/2)
    f2ypad= ceil((img.shape[1]-f2.shape[1])/2)
    f1pad = np.pad(f1,((f1xpad,f1xpad),(f1ypad,f1ypad)))
    f2pad= np.pad(f2,((f2xpad,f2xpad),(f2ypad,f2ypad)))
    return f1pad, f2pad
f1v,f2v= filters_scale(robeson,1.25)

#Use the filter computations in a function that takes an image plus scale as input, ar
# the y and x for all faces detected at that scale
def face_cord_scale(img, scale):
    f1val,f2val= filters_scale(img,scale)
```

```
    y,x = np.nonzero(np.logical_and(f1val>(20*scale),np.roll(f2val,-4,0)>(16*scale)))
    return np.dstack([x,y])

#Write one more function that will call the one above in a loop, at different scales s
# by multiples of 1.25. It should return the scale and coordinates for each detection.
def face_loops(img):
    scale=1.25
    while scale <=10:
        print("coordinates for faces at scale " + str(scale))
        f1v,f2v= filters_scale(robeson, scale)
        y,x = np.nonzero(np.logical_and(f1v>(20),np.roll(f2v,-4,0)>(16)))
        showFaces(img,x,y)
        print(face_cord_scale(img,scale))
        scale=scale+1.25
face_loops(robeson)

#reflection
# I found this project really interesting, but i definitely see the pitfalls of doing
#By trying other iamges, the detector hardly ever picted up on faces that were not whi
# because i never really thought of these programs as being able to be racist in that
#itnersting fact to come out of this. I also noticed that there were many cases where
# and white or dark shadows in pictures were picked as "faces" and im curious to see h
# inconsistent and that's a tad bit annoying.


# I did not work with anyone. I used the Numpy documentation and scikit documentation
```


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[ ]


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S-3848-2


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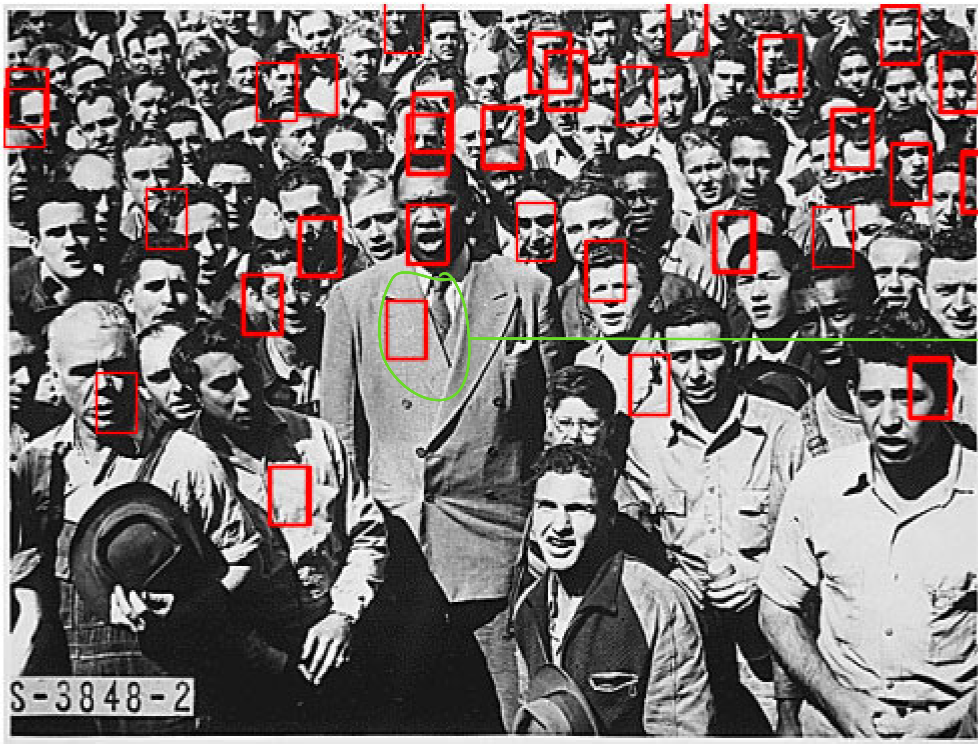
```


S-3848-2


S-3848-2



What's going on here?

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  [  65  467]
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coordinates for faces at scale 1.25
```


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```
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```

```
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coordinates for faces at scale 2.5
```
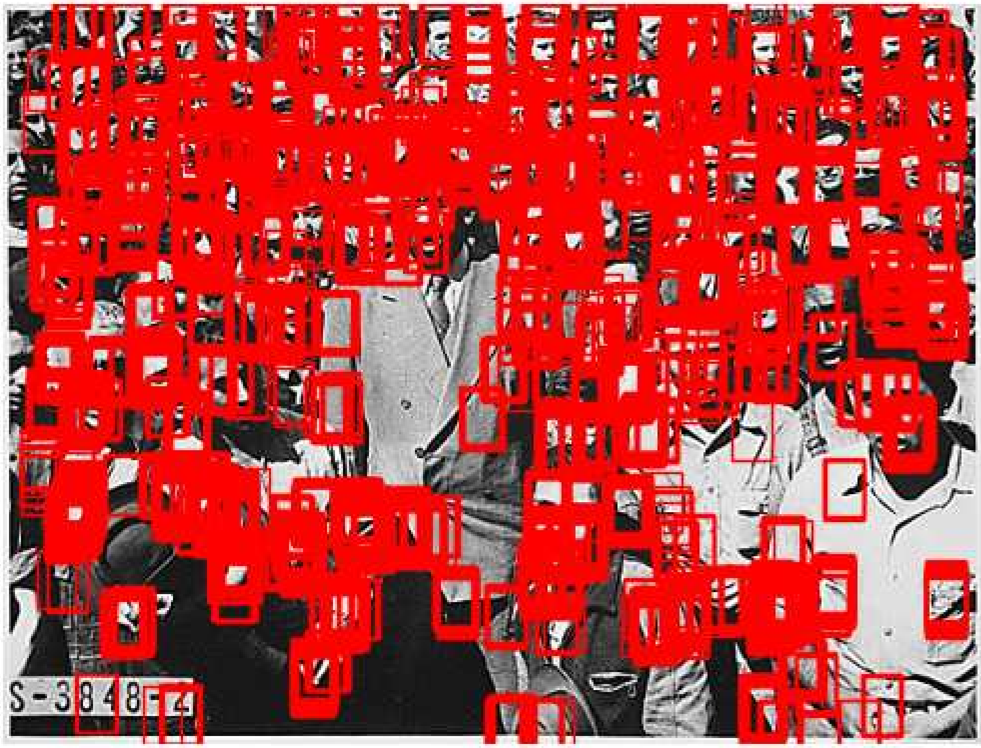
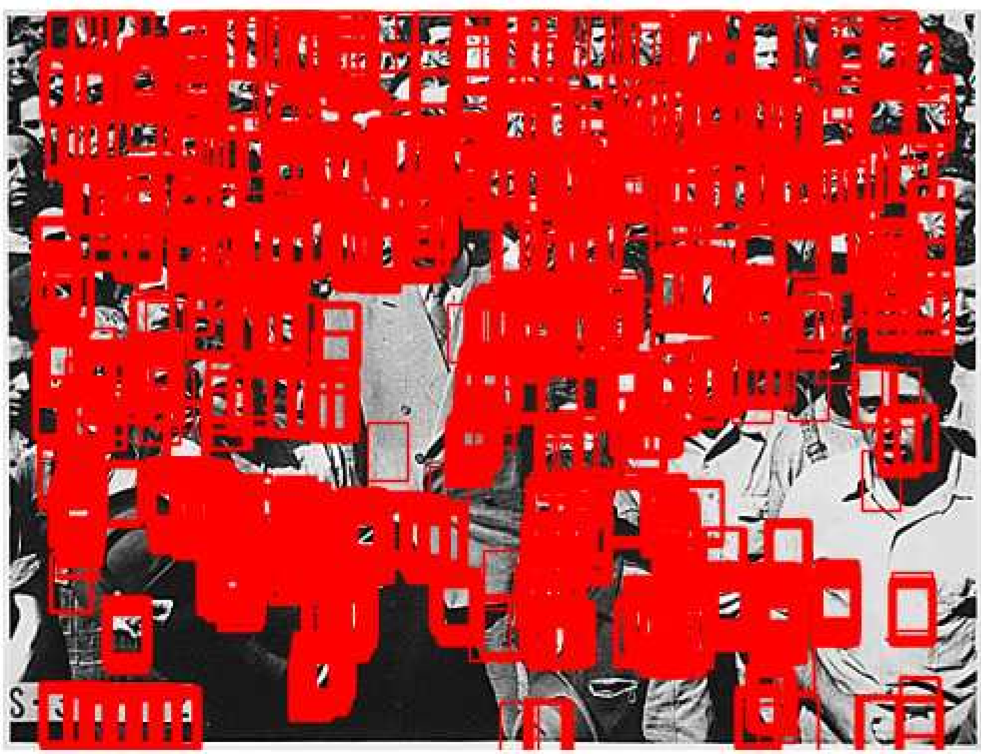


```
[]
coordinates for faces at scale 3.75
```




```
[]
coordinates for faces at scale 5.0
```



```
[]
coordinates for faces at scale 6.25
```

In [ ]:


S-3848-2