CSC320: Project 3

Face Recognition and Classification with Eigenfaces

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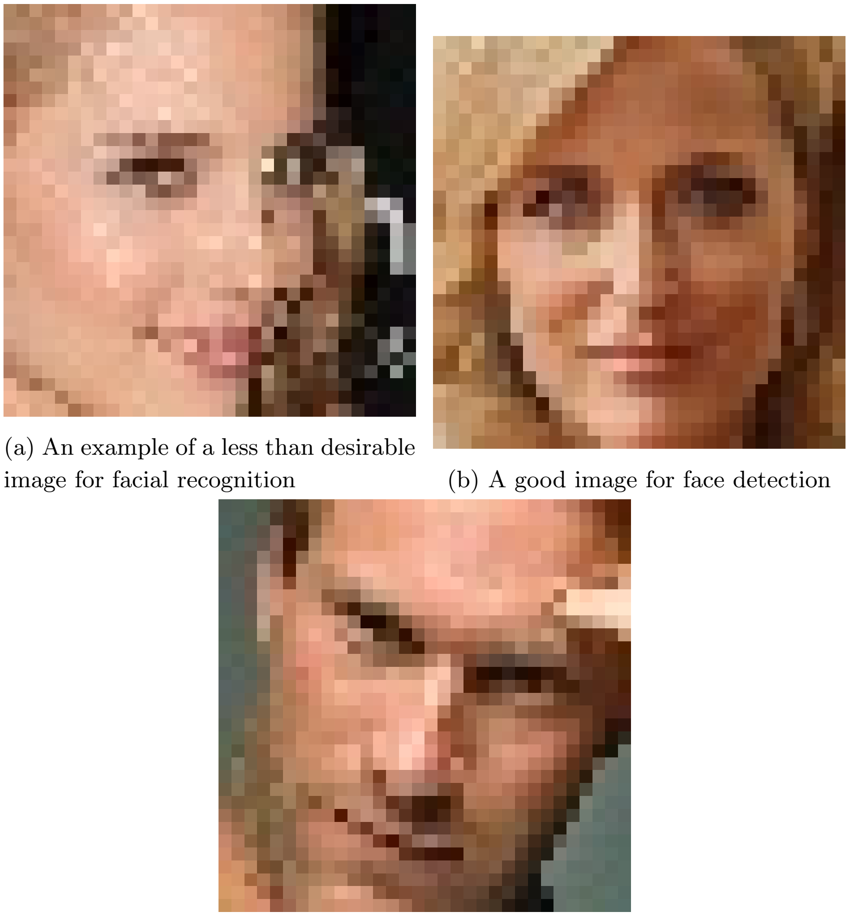
March 22, 2015

Part 1

The dataset of faces used were of popular celebrities (mainly 'Aaron Eckhart', 'Adam Sandler', 'Adrien Brody', 'Andrea Anders', 'Ashley Benson', 'Christina Applegate', 'Dianna Agron', and 'Gillian Anderson'). The images are or size 32 by 32 and have been grayscaled by using 0.299 intensity from the red channel, 0.587 from the green channel and 0.114 from the blue channel, just like in project 2. As shown in Figure 1 the cropped out faces are fairly accurate, most images can be aligned with each other but some images only show the side of the face. Thanks to a fairly large dataset we shouldn't be concerned about these 'outliers'.



(a) An example of a less than desirable image for facial recognition

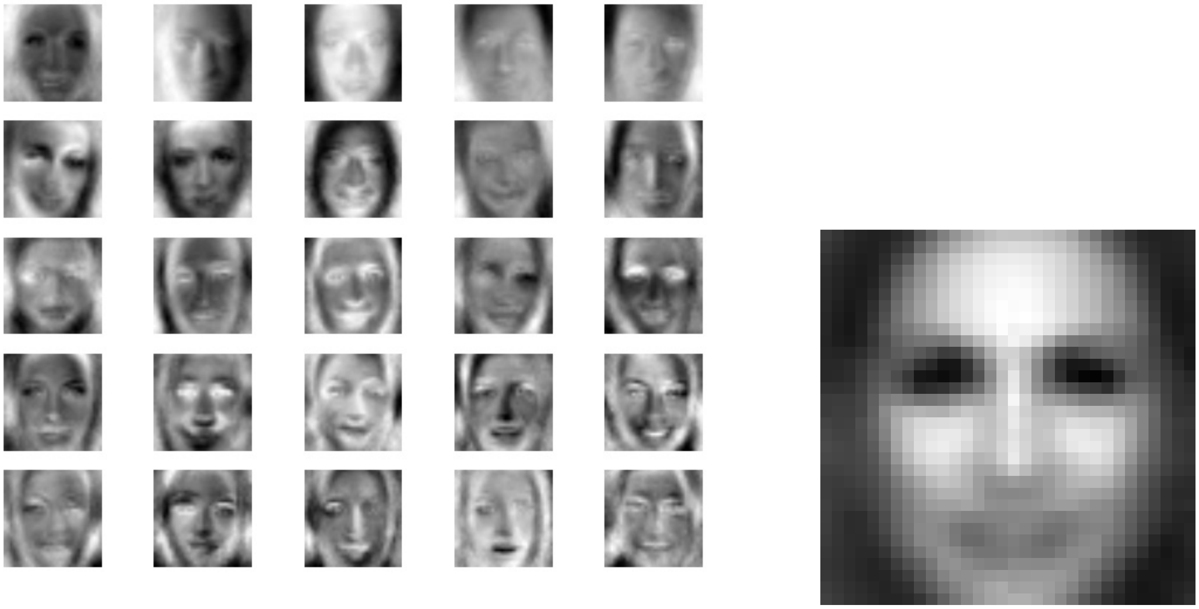
(b) A good image for face detection

(c) An alright image for face detection

Figure 1: A subset of the dataset of images used

Part 2

The dataset was seperated into 100 training images, 10 validation images, and 10 test images. This was done by just filling an array until it was full, the code is provided in the `getData()` function in the source code (for your convenience it is located in the last section of the report). Figure 2 shows 25 eigenfaces (of the 800 possible ones, 100 for each actor for a total of 8 actors) and the mean face of the training set.



(a) 25 eigenfaces from the 800 in our dataset

(b) The mean face of the eigenspace of 800 eigenfaces

Figure 2: Data generated from part 2

Part 3

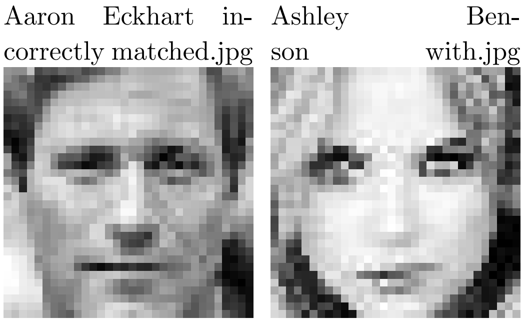
The results from running `p3.py`:

```
Training, validation, and test sets created!
Projection matrix and mean eigenface computed!
This match was incorrect, validation image 0 incorrectly matched actor 0 with 4
This match was incorrect, validation image 1 incorrectly matched actor 0 with 2
This match was incorrect, validation image 3 incorrectly matched actor 0 with 2
This match was incorrect, validation image 4 incorrectly matched actor 0 with 2
This match was incorrect, validation image 6 incorrectly matched actor 0 with 1
Performance on the validation set using 2 eigenfaces was: 22.5
Best setting for face recognition is to use 2 eigenfaces
Performance on the validation set using 5 eigenfaces was: 38.75
Best setting for face recognition is to use 5 eigenfaces
Performance on the validation set using 10 eigenfaces was: 47.5
Best setting for face recognition is to use 10 eigenfaces
Performance on the validation set using 20 eigenfaces was: 61.25
Best setting for face recognition is to use 20 eigenfaces
Performance on the validation set using 50 eigenfaces was: 66.25
Best setting for face recognition is to use 50 eigenfaces
Performance on the validation set using 80 eigenfaces was: 65.0
Best setting for face recognition is to use 50 eigenfaces
Performance on the validation set using 100 eigenfaces was: 66.25
Best setting for face recognition is to use 50 eigenfaces
Performance on the validation set using 150 eigenfaces was: 66.25
```

Part 3 continued on next page...

Best setting for face recognition is to use 50 eigenfaces
Performance on the validation set using 200 eigenfaces was: 67.5
Best setting for face recognition is to use 200 eigenfaces
Performance on the test set using 200 eigenfaces was: 50.0

Figure 3a,4a,5a,6a,7a show the 0th, 1st, 3rd, 4th, and 6th validation images in the validation set were incorrectly recognized as the images from the training set as shown in Figure 3b,4b,5b,6b,7b respectively when using only 2 eigenfaces to compute facial recognitions.



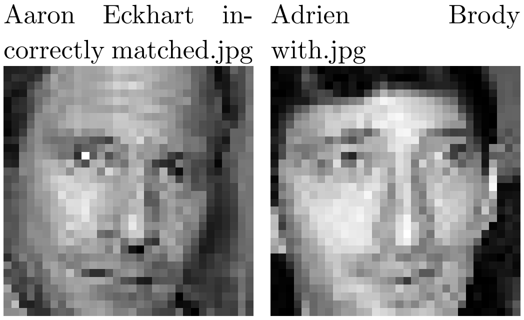
Aaron Eckhart incorrectly matched.jpg

Ashley Benson with.jpg

(a) This image was incorrectly matched with Figure 3b

(b) This recognition was computed using only 2 eigenfaces

Figure 3: Data generated from part 3



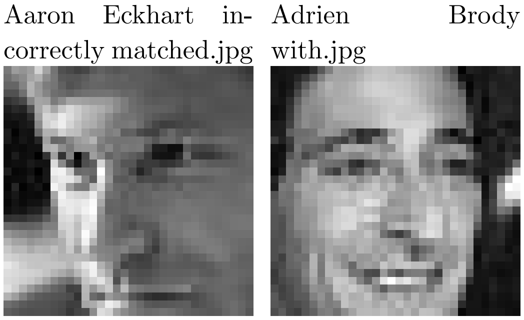
Aaron Eckhart incorrectly matched.jpg

Adrien Brody with.jpg

(a) This image was incorrectly matched with Figure 4b

(b) This recognition was computed using only 2 eigenfaces

Figure 4: Data generated from part 3



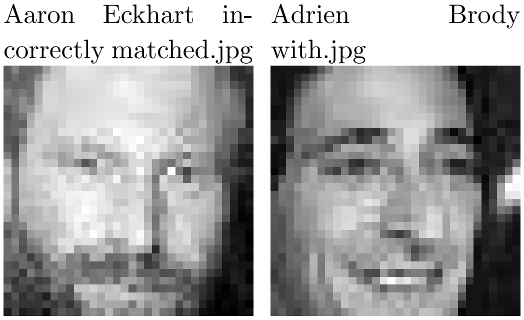
Aaron Eckhart incorrectly matched.jpg

Adrien Brody with.jpg

(a) This image was incorrectly matched with Figure 5b

(b) This recognition was computed using only 2 eigenfaces

Figure 5: Data generated from part 3



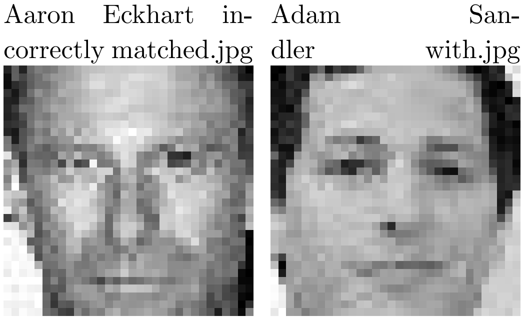
Aaron Eckhart incorrectly matched.jpg

Adrien Brody with.jpg

(a) This image was incorrectly matched with Figure 6b

(b) This recognition was computed using only 2 eigenfaces

Figure 6: Data generated from part 3



Aaron Eckhart incorrectly matched.jpg

Adam Sandler with.jpg

(a) This image was incorrectly matched with Figure 7b

(b) This recognition was computed using only 2 eigenfaces

Figure 7: Data generated from part 3

Part 4

The output of the program:

```
Performance on the validation set using 2 eigenfaces was: 75.0
Performance on the validation set using 5 eigenfaces was: 73.75
Performance on the validation set using 10 eigenfaces was: 85.0
Performance on the validation set using 20 eigenfaces was: 88.75
Performance on the validation set using 50 eigenfaces was: 92.5
Performance on the validation set using 80 eigenfaces was: 91.25
Performance on the validation set using 100 eigenfaces was: 92.5
Performance on the test set using 150 eigenfaces was: 62.5
```

p3.py:

```
from pylab import *
import numpy as np
import random
import matplotlib.cbook as cbook
import random
import time
from scipy.misc import imread
from scipy.misc import imsave
from scipy.misc import imresize
import matplotlib.image as mpimg
import matplotlib.pyplot as plt
import os


matplotlib
gray()

os.chdir('C:/Users/Ramaneek/SkyDrive/Documents/Github/CSC320-Winter-2014/project 3/')

#global variables
act = ['Aaron Eckhart', 'Adam Sandler', 'Adrien Brody', 'Andrea Anders', 'Ashley
    Benson', 'Christina Applegate', 'Dianna Agron', 'Gillian Anderson']
training_set = np.zeros((len(act)*100, 32*32)) - 1 #need to use zeros()!!
validation_set = np.zeros((len(act)*10, 32*32)) - 1 #32*32 since a 32x32 matrix is
    flattened
test_set = np.zeros((len(act)*10, 32*32)) - 1

#fills in the global variable data
def getData():
   count_tr = 0 #training
   count_va = 0 #validation
   count_te = 0 #testing
   k = 135 #every actor has at least 135 pics

   for a in act:
      name = a.split()[1].lower()
      for i in range(k):
         if i == k:
            print "You might want to get more images or lower the training set amount"
            exit()

         if os.path.isfile("cropped/"+name+str(i)+".jpg"):
            #print "JPG"
            img = imread("cropped/"+name+str(i)+".jpg")
         elif os.path.isfile("cropped/"+name+str(i)+".png"):
            #print "PNG"
            img = imread("cropped/"+name+str(i)+".png")
         else: #couldn't open this image
```

```
            #print "trying next image"
            continue

         #need to convert img to gray scale
         gray_img = 0.299*img[:,:,0] + 0.587*img[:,:,1] + 0.114*img[:,:,2]
         #if training_set[(act.index(a)+1)*100,-1] == -1: #get 100 training images for this actor
         if count_tr < (act.index(a)+1) * 100:
            training_set[count_tr][:] = gray_img.flatten()
            count_tr += 1
         elif count_va < (act.index(a)+1) * 10: #get 10 validation images for this actor
            validation_set[count_va][:] = gray_img.flatten()
            count_va += 1
         elif count_te < (act.index(a)+1) * 10: #get 10 test images for this actor
            test_set[count_te][:] = gray_img.flatten()
            count_te += 1
         else: #got all the pictures needed for this actor, move on to next actor
            break
   print "Training, validation, and test sets created!"

def pca(X):
   """  Principal Component Analysis
      input: X, matrix with training data stored as flattened arrays in rows
      return: projection matrix (with important dimensions first), variance and mean.
      From: Jan Erik Solem, Programming Computer Vision with Python
      #http://programmingcomputervision.com/
   """

   # get dimensions
   num_data,dim = X.shape

   # center data
   mean_X = X.mean(axis=0)
   X = X - mean_X

   if dim>num_data:
      # PCA - compact trick used
      M = dot(X,X.T) # covariance matrix
      e,EV = linalg.eigh(M) # eigenvalues and eigenvectors
      tmp = dot(X.T,EV).T # this is the compact trick
      V = tmp[::-1] # reverse since last eigenvectors are the ones we want
      S = sqrt(e)[::-1] # reverse since eigenvalues are in increasing order
      for i in range(V.shape[1]):
         V[:,i] /= S
   else:
      # PCA - SVD used
      U,S,V = linalg.svd(X)
      V = V[:num_data] # only makes sense to return the first num_data

   # return the projection matrix, the variance and the mean
   print "Projection matrix and mean eigenface computed!"
   return V,S,mean_X
```

```

def ssd(x, y):
   return sum((x.flatten().astype(float)-y.flatten().astype(float))**2)

def display_save_25_comps(V, im_shape):
   '''Display 25 components in V'''
   figure()
   for i in range(25):
      plt.subplot(5, 5, i+1)
      plt.axis('off')
      gray()
      imshow(V[i,:].reshape(im_shape))
   savefig('report/display_save_25_comps.jpg')
   show()

####################################################################################################

getData() #get the data from the cropped images and fill in some of the global variables

projection_M, variance, mean_img = pca(training_set) #we actually don't even need the variance in this project
display_save_25_comps(projection_M, (32,32))
average_face = np.reshape(mean_img, (32,32)) #keep this to show later on in the report
imsave("report/mean_face.jpg", average_face)

validation_settings = [2, 5, 10, 20, 50, 80, 100, 150, 200] # the top k eigenfaces

#Validation set
max_performance = 0 #for determining the most correct setting for how many eigenfaces to use
best_setting = 0
num_incorrect = 0 #for displaying incorrect matches for reporting purposes

for setting in validation_settings:
   num_correct = 0
   for i in range(validation_set.shape[0]):

      #project the validation image on to the eigenface space
      val_proj_img = np.dot(projection_M[:setting], validation_set[i] - mean_img)
      validation_name_index = int(i/10)

      #compute the closest projected training face to identify validation_set[i]
      min = Infinity
      for j in range(training_set.shape[0]):
         train_proj_img = np.dot(projection_M[:setting], training_set[j] - mean_img)
         ssd_value = ssd(val_proj_img, train_proj_img)
         if ssd_value < min:
            #print "found new min:", int(j/100)
            min = ssd_value
            #the index of the actor's name
            training_name_index = int(j/100)
            raw_training_name_index = j
```

```
        #print ssd_value
        #print validation_name, training_name
        if validation_name_index == training_name_index:
            num_correct += 1
            #print "\t found match"
        elif num_incorrect < 5:
            num_incorrect += 1
            print "This match was incorrect, validation image", i, "incorrectly matched
                actor", validation_name_index, "with ", training_name_index
            imsave("report/"+str(num_incorrect)+"_"+act[validation_name_index]+"_incorrectly_matched.jpg
                np.reshape(validation_set[i], (32,32)))
            imsave("report/"+str(num_incorrect)+"_"+act[training_name_index]+"_with.jpg",
                np.reshape(training_set[raw_training_name_index], (32,32)))


    performance = num_correct * 100.0 / validation_set.shape[0]
    print "Performance on the validation set using", setting, "eigenfaces was: ",
        performance
    if max_performance < performance:
        max_performance = performance
        best_setting = setting
    print "Best setting for face recognition is to use", best_setting, "eigenfaces"

#test set
num_correct = 0
for i in range(test_set.shape[0]):
    test_proj_img = np.dot(projection_M[:best_setting], test_set[i] - mean_img)
    test_name_index = int(i/10)

    #compute the closest projected training face to identify validation_set[i]
    min = Infinity
    for j in range(training_set.shape[0]):
        train_proj_img = np.dot(projection_M[:best_setting], training_set[j] - mean_img)
        ssd_value = ssd(test_proj_img, train_proj_img)
        if ssd_value < min:
            min = ssd_value
            #the index of the actor's name
            training_name_index = int(j/100)

    if test_name_index == training_name_index:
        num_correct += 1

performance = num_correct * 100.0 / test_set.shape[0]
print "Performance on the test set using", best_setting, "eigenfaces was: ",
    performance

# Part 3 is done


## Part 4 begin
print "\n\n\nNOW TESTING GENDER RECOGNITION\n\n\n"
```

```
#Validation set
max_performance = 0 #for determining the most correct setting for how many eigenfaces to use
best_setting = 0
num_incorrect = 0 #for displaying incorrect matches for reporting purposes

for setting in validation_settings:
   num_correct = 0
   for i in range(validation_set.shape[0]):
      #project the validation image on to the eigenface space
      val_proj_img = np.dot(projection_M[:setting], validation_set[i] - mean_img)
      validation_name_index = int(i/10)

      #compute the closest projected training face to identify validation_set[i]
      min = Infinity
      for j in range(training_set.shape[0]):
         train_proj_img = np.dot(projection_M[:setting], training_set[j] - mean_img)
         ssd_value = ssd(val_proj_img, train_proj_img)
         if ssd_value < min:
            min = ssd_value
            training_name_index = int(j/100)

      if validation_name_index >= 3 and training_name_index >= 3: #both female
         num_correct += 1
         #print "found match"
      elif validation_name_index < 3 and training_name_index < 3: #both male
         num_correct += 1
      elif num_incorrect < 5:
         num_incorrect += 1
         #print "This match was incorrect, validation image", i, "incorrectly matched actor", validation_name_index, "with ", training_name_index
         #imsave(str(num_incorrect)+act[validation_name_index]+"gender_incorrectly_matched_with"+act


   performance = num_correct * 100.0 / validation_set.shape[0]
   print "Performance on the validation set using", setting, "eigenfaces was: ", performance
   if max_performance < performance:
      max_performance = performance
      best_setting = setting

#test set
num_correct = 0
for i in range(test_set.shape[0]):
   test_proj_img = np.dot(projection_M[:best_setting], test_set[i] - mean_img)
   validation_name_index = int(i/10)
   #compute the closest projected training face to identify validation_set[i]
   min = Infinity
   for j in range(training_set.shape[0]):
      train_proj_img = np.dot(projection_M[:best_setting], training_set[j] - mean_img)
      ssd_value = ssd(test_proj_img, train_proj_img)
      if ssd_value < min:
         min = ssd_value
         training_name = int(j/100)

   if validation_name_index >= 3 and training_name_index >= 3: #both female
      num_correct += 1
      #print "found match"
   elif validation_name_index < 3 and training_name_index < 3: #both male
      num_correct += 1

performance = num_correct * 100.0 / test_set.shape[0]
print "Performance on the test set using", best_setting, "eigenfaces was: ",
    performance

# End part 4
```

get data.py

```
#for downloading the image data
from pylab import *
import numpy as np
import matplotlib.pyplot as plt
import matplotlib.cbook as cbook
import random
import time
from scipy.misc import imread
from scipy.misc import imresize
import matplotlib.image as mpimg
import os
from scipy.ndimage import filters
import urllib


os.chdir('C:/Users/Ramaneek/SkyDrive/Documents/Github/CSC320-Winter-2014/project 3/')

act = ['Aaron Eckhart', 'Adam Sandler', 'Adrien Brody', 'Andrea Anders', 'Ashley
    Benson', 'Christina Applegate', 'Dianna Agron', 'Gillian Anderson']





def timeout(func, args=(), kwargs={}, timeout_duration=0.5, default=None):
   '''From:
   http://code.activestate.com/recipes/473878-timeout-function-using-threading/'''
   import threading
   class InterruptableThread(threading.Thread):
      def __init__(self):
         threading.Thread.__init__(self)
         self.result = None

      def run(self):
         try:
                self.result = func(*args, **kwargs)
            except:
                self.result = default

    it = InterruptableThread()
    it.start()
    it.join(timeout_duration)
    if it.isAlive():
        return False
    else:
        return it.result

testfile = urllib.URLopener()


#Note: you need to create the uncropped folder first in order
#for this to work

for a in act:
    name = a.split()[1].lower()
    i = 0
    for line in open("faces_subset.txt"):
        if a in line:
            # line.split()[-2] gives the x1,y1,x2,y2 coordinates for specific image in this line
            coordinates = line.split()[-2].split(',') #an array of x1,y1,x2,y2 coordinates

            #filename = actorname + number of pics of this actor + filename
            filename = name+str(i)+'.'+line.split()[4].split('.')[-1]
            #A version without timeout (uncomment in case you need to
            #unsupress exceptions, which timeout() does)
            #testfile.retrieve(line.split()[4], "uncropped/"+filename)
            #timeout is used to stop downloading images which take too long to download
            timeout(testfile.retrieve, (line.split()[4], "uncropped/"+filename), {}, 30)
            print "saved original file:" + filename

            if os.path.isfile("uncropped/"+filename): #if the image has been saved
                #need to open this image and crop it
                #no point converting it to grayscale here since imsave saves it as a 3D array

                #check to see if image can be read
                try:
                    image_cropped = imread("uncropped/"+filename)
                    image_cropped = image_cropped[int(coordinates[1]):int(coordinates[3]) , int(coordinates[0]):int(coordinates[2])]
                    #now lets resize image to 32x32
                    image_cropped = imresize(image_cropped, (32,32))
                    imsave("cropped/"+filename, image_cropped)
                    print "saved cropped file: " + filename
                except Exception:
                    print "cant open file: " + filename
                    continue

        else:
            print "CONTINUING!!!!!!!!!!!!!!!!!"
            continue


        i += 1
```