Part 1

Eigenface1

Eigenface2

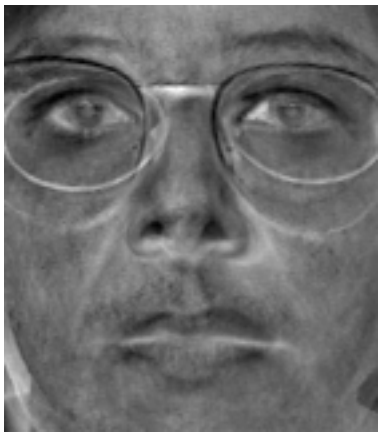
Eigenface3

Eigenface4

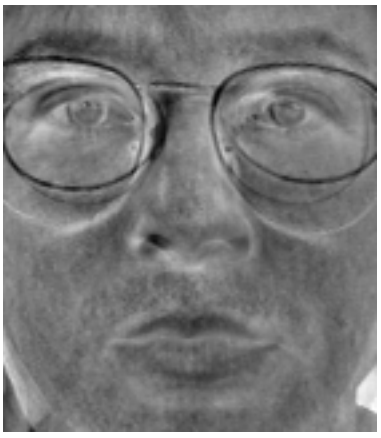
Eigenface5

Eigenface6

Eigenface7



Eigenface8



mean

Part 2

```
Z is a matrix of (30 X 10)
Z=
[[ -1.13769145e+03   7.55086221e+03   2.02984275e+03   1.88527800e+03
   -2.46748086e+03  -3.72463517e+03  -7.51045582e+02  -5.70269268e+02
   -1.86359242e+03  -9.51268152e+02]
 [  2.13462352e+02  -1.38555042e+03  -1.18813869e+02  -3.71542904e+02
   -7.45190856e+01   1.04251570e+03  -4.75444764e+02   1.41890068e+02
   -1.00524673e+02   1.12852757e+03]
 [  1.07682504e+03   5.74376847e+02  -9.76900724e+02  -8.91841231e+02
    1.14916031e+02   1.44119005e+03   2.54853266e+03   9.16676692e+02
    4.80563285e+02  -5.28433860e+03]
 [  2.44559654e+03   7.28452957e+02  -6.90080532e+02   2.41053039e+02
   -1.51576084e+03   2.05243783e+03  -8.90615603e+02  -2.08237636e+03
   -5.90275161e+02   3.01568139e+02]
 [  5.54546739e+02   3.54849480e+02   1.42812367e+03   1.45410884e+03
   -1.41981214e+03  -1.04159128e+03  -6.17318993e+01   9.40990100e+02
   -1.39183160e+03  -8.17651926e+02]
 [  2.23232671e+02  -7.86725899e+02   1.06282453e+03   1.37766345e+03
    7.89615576e+02  -8.87492807e+02   3.46591978e+02  -2.33324750e+03
    9.77737513e+02  -7.70199517e+02]
 [  1.20321206e+03   1.02921324e+03  -5.87978895e+02  -5.34254688e+02
    1.43295692e+03  -1.21348987e+03  -1.57019032e+03   2.09045260e+02
    4.80328850e+02  -4.48842536e+02]
 [ -8.77268442e+02  -2.56350617e+02   2.58334381e+02   1.22399558e+03
    3.59893929e+02   1.31554271e+03  -1.88849314e+03   5.88228054e+02
    1.38264651e+02  -8.62147111e+02]
 [ -6.98656800e+02   4.54779634e+02   1.02310290e+03  -1.05930616e+03
   -4.73269416e+02   4.90393174e+02  -2.98617310e+02  -3.71810280e+02
    1.14899847e+03  -2.15614198e+02]
 [  7.93291546e+02  -7.47127644e+02   1.32537605e+02  -6.14641617e+01
   -1.25963063e+03  -5.39887427e+02  -4.02667340e+02   7.06384982e+02
    1.36979292e+03   8.77014106e+00]
 [  5.60346606e+02  -4.02376727e+02   1.32444688e+03  -1.02277782e+03
    4.34809966e+02   1.77112787e+02  -2.56369742e+02   4.65021884e+01
   -7.88062141e+02  -7.36320145e+01]
 [ -4.01777091e+02   8.69942687e+02   9.21637698e+01  -1.17390650e+02
   -2.78280943e+02  -6.89108696e+01   3.26219196e+01  -2.53093848e+02
    1.10955488e+02   1.37694686e+01]
 [  1.84707666e+01  -9.54593514e+00  -8.35121338e+01   1.16222653e+02
    5.62903095e+01   4.97291290e+00   2.72493685e+01   1.76637884e+01
   -4.25543967e+01  -1.05257287e+02]
 [  1.92480429e+01  -1.62261160e+02  -6.33325740e+01  -2.31398032e+01
    4.12847181e+01   2.00985254e+01   3.93040312e+01   1.72431964e+01
    4.44369013e+01   6.71181322e+01]
 [ -1.73325837e+01  -3.31236869e+01   9.99948368e+00   1.84195189e+01
    6.68575807e+01   2.96699354e+01   2.47997944e+01  -5.17151873e+01
   -3.36274018e+01  -1.39474628e+01]
 [  4.22005294e+01  -2.39406725e+02  -1.58897162e+01   7.00205972e+01
    8.99591505e+01   4.72350484e+01   7.20602070e+01  -4.06799908e+01
    3.11187463e+00  -2.86109605e+01]
 [ -4.22900151e-01  -3.84918991e+01   6.60607034e+01   1.79376756e+00
    1.26014916e+01   4.96491907e+01  -6.41949686e+00  -2.58609941e+01
   -4.27891825e+01  -1.61206897e+01]
 [ -4.30794368e+01   1.63988414e+01   3.85360949e+01  -1.26887831e+01
    2.01198786e+01  -1.74829915e+00   1.34941477e+01   3.71014378e+01
   -2.11943285e+01  -4.69395718e+01]
 [ -4.55959693e+01   2.50804560e+01  -5.60402894e+01  -2.00620025e+01
    1.61352478e+01  -1.54579072e+01   2.01331843e+01   1.62233145e+01
    4.38941842e+01   1.56897760e+01]
```

```
[ -4.32341242e+01  -1.05516167e+01   3.43653336e+01   2.55664956e+01
   8.95689427e+00   9.56966329e+00  -2.67460892e+00  -5.31171679e+00
  -1.17278848e+01  -4.95844843e+00]
[ -2.56434501e+01  -4.57557950e-02  -4.73043428e+01   1.09746340e+01
  -2.12066026e+01   1.24421866e+02  -5.53824713e+01   1.50514005e+01
  -4.70139715e+01   4.61486546e+01]
[  2.29218937e+01   6.52573911e+00  -2.96511842e+01  -1.17042351e+01
  -6.41717313e+00   3.71023466e+01  -6.57449905e+00  -4.38496057e+01
   3.18320431e+01  -1.85367079e-01]
[  1.31784348e+01   3.41399468e+01   2.00665488e+01   4.22568460e+01
   3.64512724e+01  -2.66162680e+01  -8.13354463e+01  -3.34124312e+01
  -1.17863186e+01   7.05746245e+00]
[ -7.96347640e+00   5.03270937e+00  -2.41918731e+01   2.20353027e+01
  -2.45028562e+01  -7.93104962e+00   2.39311924e+01   2.54684066e+01
  -2.60578971e+01   1.41795488e+01]
[  2.59661018e+01   2.77710786e+01  -2.73682956e+00   8.20730503e+00
  -2.39743049e+01  -2.58580618e+01  -1.86739439e+01  -1.43261066e+01
   4.92831788e+00   1.86964470e+01]
[  9.86495253e+00   2.08769165e+01  -1.39751718e+01   6.88403882e+00
   1.69650475e+01   1.14178834e+01  -1.83150902e+01  -4.03498976e+01
   1.96989473e+01  -1.30675627e+01]
[ -4.91586708e+01   2.70597484e+01   5.46647264e+01   9.76401659e+00
  -2.01790009e+01   3.03312169e+01   2.37467673e+01  -5.27597043e+01
  -2.20575721e+01  -1.41152886e+00]
[  1.03607066e+01  -5.75713259e+00   5.07261943e+00  -1.42643603e+01
  -3.32720301e+00   6.01140527e+00   9.78450689e+00   2.71752113e+01
  -2.55474169e+01  -9.50833571e+00]
[  2.34952598e+01  -9.36320057e+00   2.26871330e+01   5.65816777e+00
  -1.03928909e+01  -1.62381590e+01  -2.33372873e+01   2.34365496e+01
   1.27997779e+01  -2.87453724e+01]
[ -1.14833313e+01   2.18736011e+01  -2.68443627e+01  -5.98290658e+00
   1.26065004e+01   2.83712247e+00  -2.34758223e+01  -8.87270305e-01
   2.30664505e+01   8.29000635e+00]]
```

Part 3

(a) Confusion Matrix? Accuracy of A?

Confusion Matrix

```
[[  7.   2.   0.   0.   0.   3.   0.   0.   0.   0.]
 [  0.  12.   0.   0.   0.   0.   0.   0.   0.   0.]
 [  0.   2.   8.   0.   2.   0.   0.   0.   0.   0.]
 [  0.   2.   0.   8.   2.   0.   0.   0.   0.   0.]
 [  0.   2.   0.   0.  10.   0.   0.   0.   0.   0.]
 [  0.   2.   0.   0.   0.   7.   0.   0.   3.   0.]
 [  0.   2.   0.   0.   0.   2.   8.   0.   0.   0.]
 [  0.   2.   0.   0.   0.   1.   0.   9.   0.   0.]
 [  0.   2.   0.   0.   0.   0.   0.   0.  10.   0.]
 [  0.   2.   0.   0.   0.   0.   0.   0.   0.  10.]]
```

Accuracy of A (K=30)= 0.741666666667

(b) Which one has largest Value for all the off-diagonal entries in the Confusion Matrix?

Confusion Matrix [0 , 5] and Confusion Matrix [5 , 8] are equal to "3," which is largest value for all the off-diagonal entries.

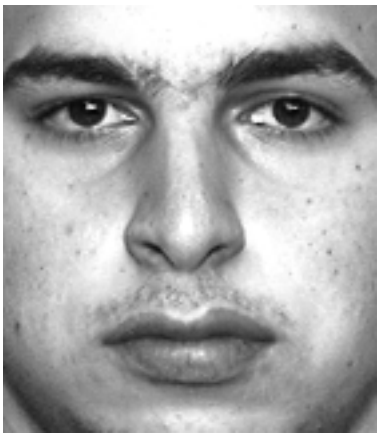
```
[[  7.   2.   0.   0.   0.   3.   0.   0.   0.   0.]
 [  0.  12.   0.   0.   0.   0.   0.   0.   0.   0.]
 [  0.   2.   8.   0.   2.   0.   0.   0.   0.   0.]
 [  0.   2.   0.   8.   2.   0.   0.   0.   0.   0.]
 [  0.   2.   0.   0.  10.   0.   0.   0.   0.   0.]
 [  0.   2.   0.   0.   0.   7.   0.   0.   3.   0.]
 [  0.   2.   0.   0.   0.   2.   8.   0.   0.   0.]
 [  0.   2.   0.   0.   0.   1.   0.   9.   0.   0.]
 [  0.   2.   0.   0.   0.   0.   0.   0.  10.   0.]
 [  0.   2.   0.   0.   0.   0.   0.   0.   0.  10.]]
```

(c) Two faces of R and C

I found two combinations for largest off-diagonal entries. These two combination are indeed similar comparing to other people.

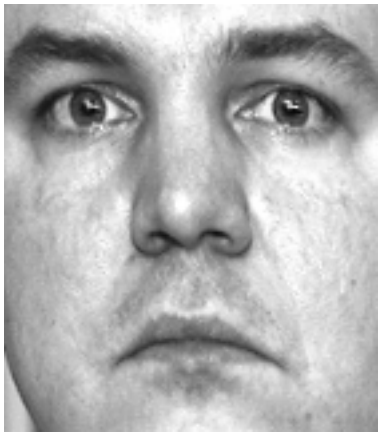
[R , C] = [0 , 5] => Person 1 and Person 6

04010_27_11.bmp 04015_27_11.bmp




[R , C] = [5 , 8] => Person 6 and Person 9

04015_27_11.bmp 04018_27_11.bmp

(d) Is there an entire column (or row) in the Confusion Matrix that is non-zero? If so, display that face, and suggest an explanation why this face is problematic.

Second column of Confusion Matrix [: , 1] is non-zero.

After checking the Euclidean Distance Result, the error comes from the first two images out of each person's 12 images. The value of Euclidean Distance Result of "first two images of each person" and "second column of Z matrix" is much smaller. The first two images of each person in test data set are too dim/dark so that classifier recognize them as second person with black skin (second classifier in Z matrix).

The problem comes from the similarity of second people (identity: 04011)

```
[[  7.   2.   0.   0.   0.   3.   0.   0.   0.   0.]
 [  0.  12.   0.   0.   0.   0.   0.   0.   0.   0.]
 [  0.   2.   8.   0.   2.   0.   0.   0.   0.   0.]
 [  0.   2.   0.   8.   2.   0.   0.   0.   0.   0.]
 [  0.   2.   0.   0.  10.   0.   0.   0.   0.   0.]
 [  0.   2.   0.   0.   0.   7.   0.   0.   3.   0.]
 [  0.   2.   0.   0.   0.   2.   8.   0.   0.   0.]
 [  0.   2.   0.   0.   0.   1.   0.   9.   0.   0.]
 [  0.   2.   0.   0.   0.   0.   0.   0.  10.   0.]
 [  0.   2.   0.   0.   0.   0.   0.   0.   0.  10.]]
```

Faces of second person in train data set

(e) What do you observe?

The accuracy of A is going up as K increasing from 5 to 20, but it reaches the maximum as accuracy of 0.75. And then after K=20, it goes to the same level as K increase. I also try K=35 with the same accuracy result as K=30.

A (K=5) = 0.391666666667

A (K=6) = 0.433333333333

A (K=8) = 0.533333333333

A (K=10) = 0.666666666667

A (K=15) = 0.741666666667

A (K=20) = 0.75

A (K=25) = 0.741666666667

A (K=30) = 0.741666666667

PLOT OF A