Homework5

June 7, 2018

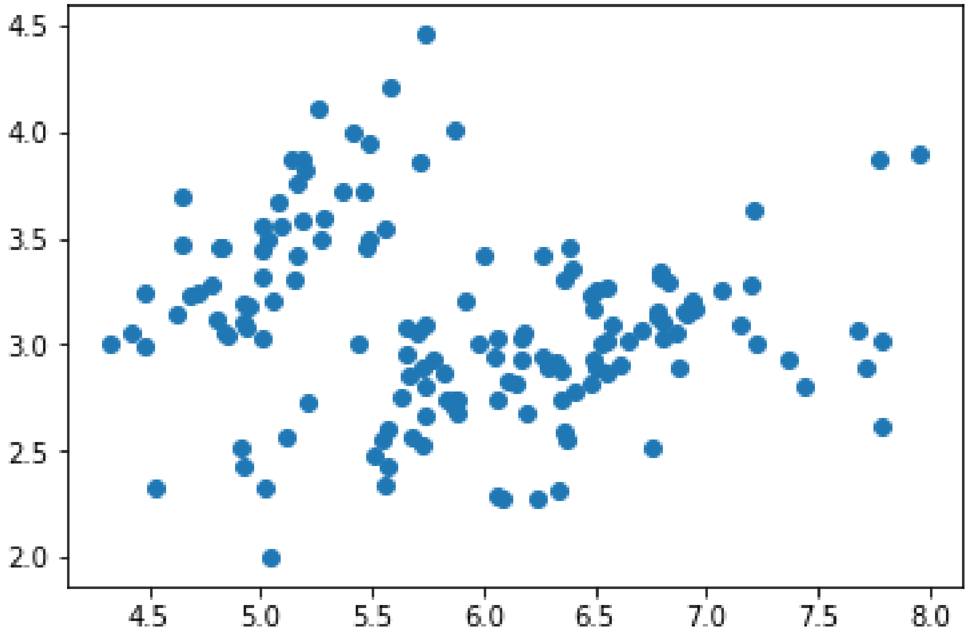
1 CS 273P | Homework 5

Shefali Gupta | 57806943

```
In [39]: import numpy as np
         np.random.seed(0)
         import mltools as ml
         import matplotlib.pyplot as plt
         import time
         from sklearn.preprocessing import OneHotEncoder
         import warnings
         warnings.filterwarnings('ignore')
         %matplotlib inline
```

Problem 1 :

```
In [40]: import mltools.cluster as clust
         #reload(clust);

In [41]: iris=np.genfromtxt("data/iris.txt",delimiter=None)
         Y=iris[:,-1]
         X=iris[:,0:2] # (148,2)

In [42]: plt.figure()
         plt.scatter(X[:,0],X[:,1])
         plt.show()
         print("The figure shows approximately 4 clusters")
```



```
The figure shows approximately 4 clusters
```

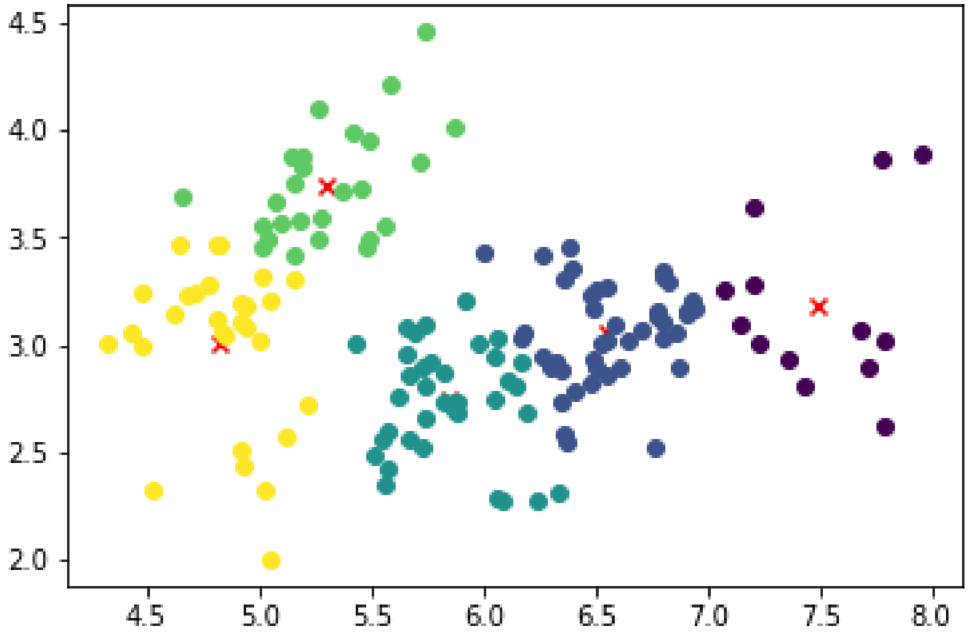
Problem 1 b:

```
In [43]: # k-means
         # k=5
         ssd=np.inf
         for i in range(10):
             Zi,mui,ssdi=clust.kmeans(X,K=5,init='random')
             print(i,ssdi)
             if ssdi<ssd:
                 Z,mu,ssd=Zi,mui,ssdi
         #Now,plot the data and their cluster ID as color:
         ml.plotClassify2D(None,X,Z)
         plt.scatter(mu[:,0],mu[:,1],c='r',marker='x')
```

```
0 23.438643757297644
1 25.403909282771348
2 24.32039355047388
3 21.66938725646046
4 20.856963620246418
5 26.655013472609337
6 25.671305957870096
7 24.32039355047388
8 20.867217448173573
```

```
9 21.474609331235506
```

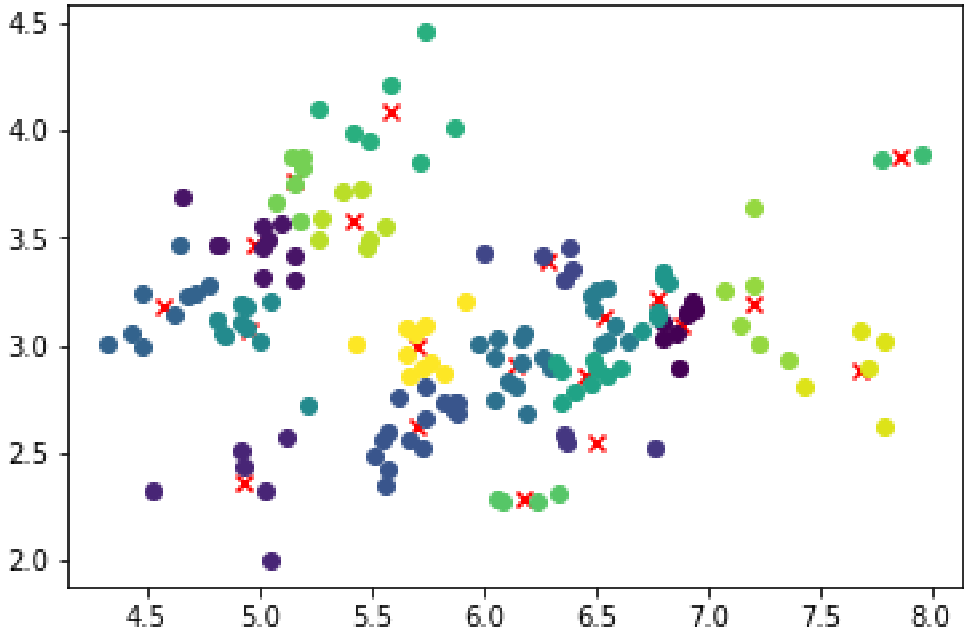
```
Out[43]: <matplotlib.collections.PathCollection at 0x116e0cbe0>
```



```
In [44]: # k=20
         ssd=np.inf
         for i in range(10):
             Zi,mui,ssdi=clust.kmeans(X,K=20,init='random')
             print(i,ssdi)
             if ssdi<ssd:
                 Z,mu,ssd=Zi,mui,ssdi
         #Now,plot the data and their cluster ID as color:
         ml.plotClassify2D(None,X,Z)
         plt.scatter(mu[:,0],mu[:,1],c='r',marker='x')
```

```
0 4.8001479642817255
1 4.49904759523533
2 4.936736713021152
3 5.248772814771274
4 5.701485748609772
5 5.395255830956612
6 5.442582698020821
7 5.994015256416024
8 6.018268730030417
9 4.571853233395967
```

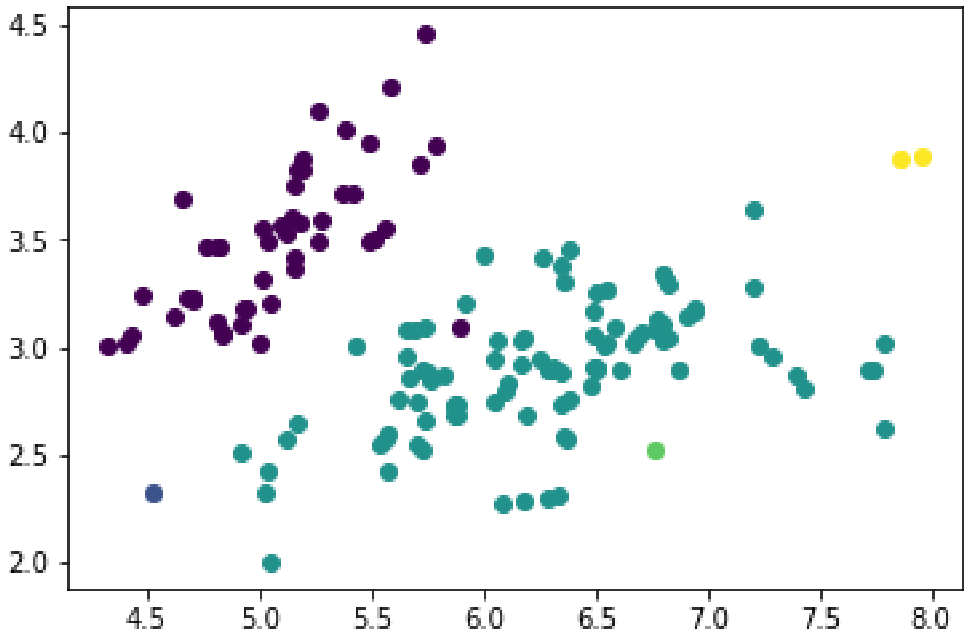
```
Out[44]: <matplotlib.collections.PathCollection at 0x116e0cb70>
```



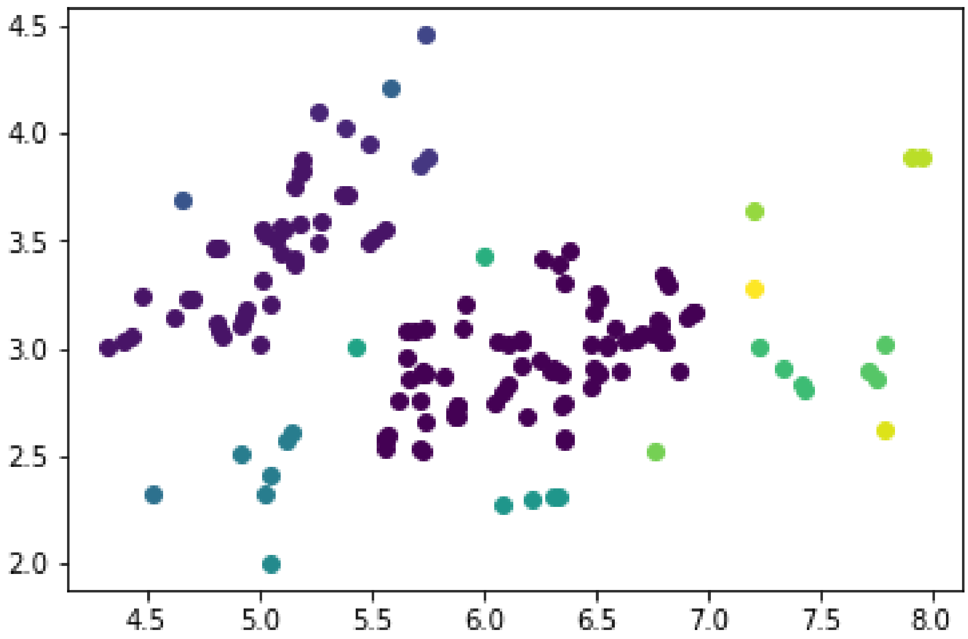
Problem 1 c : Agglomerative clustering

```
In [45]: Z,dend=clust.agglomerative(X,K=5,method='min')
         plt.figure()
         print("Single linkage, K=5")
         ml.plotClassify2D(None,X,Z)
         plt.show()

         Z,dend=clust.agglomerative(X,K=20,method='min')
         plt.figure()
         print("Single linkage, K=20")
         ml.plotClassify2D(None,X,Z)
         plt.show()

         Z,dend=clust.agglomerative(X,K=5,method='max')
         plt.figure()
         print("Complete linkage, K=5")
         ml.plotClassify2D(None,X,Z)
         plt.show()

         Z,dend=clust.agglomerative(X,K=20,method='max')
         plt.figure()
         print("Complete linkage, K=20")
         ml.plotClassify2D(None,X,Z)
         plt.show()
```

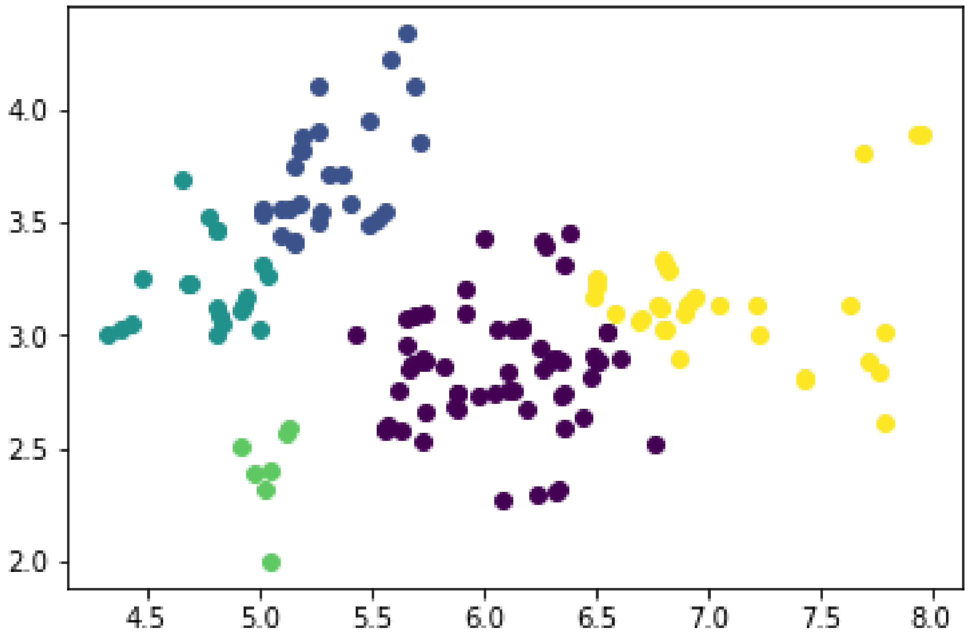
```
Single linkage, K=5
```



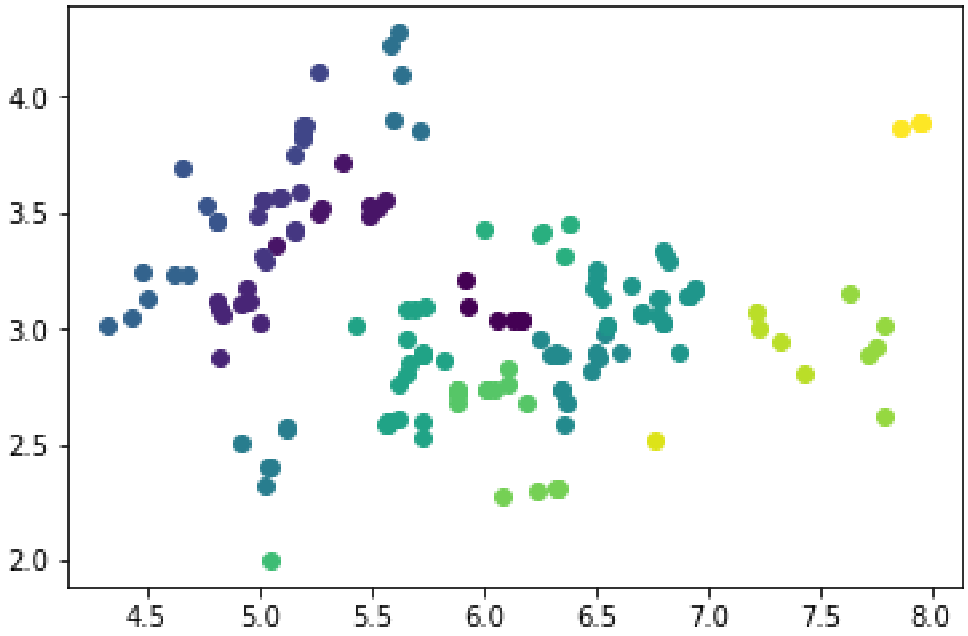
```
Single linkage, K=20
```



```
Complete linkage, K=5
```



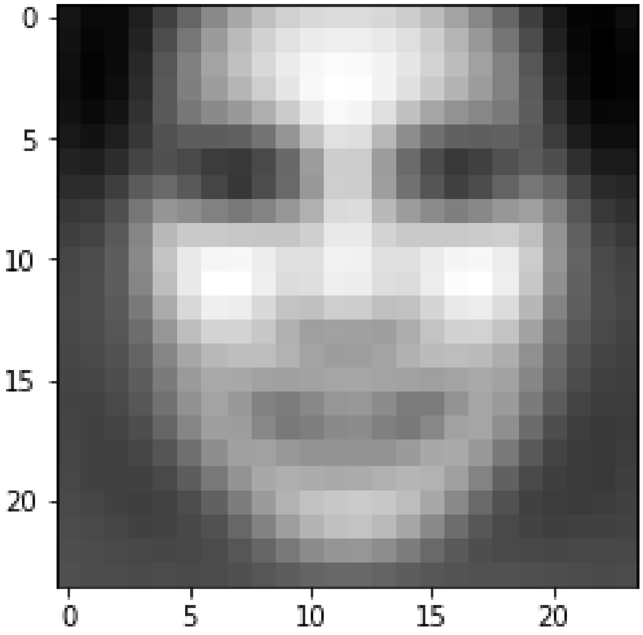
```
Complete linkage, K=20
```



K-means works well when the shape of clusters are hyper-spherical. Agglomerative clustering builds clusters incrementally. Problem 2: Eigen Faces

```
In [46]: X=np.genfromtxt("data/faces.txt",delimiter=None)
         mu=X.mean(axis=0,keepdims=True)
         X0=X-mu
         plt.figure()
         img=np.reshape(mu,(24,24))
         plt.imshow(img.T,cmap="gray")
```

```
Out[46]: <matplotlib.image.AxesImage at 0x11cb71240>
```

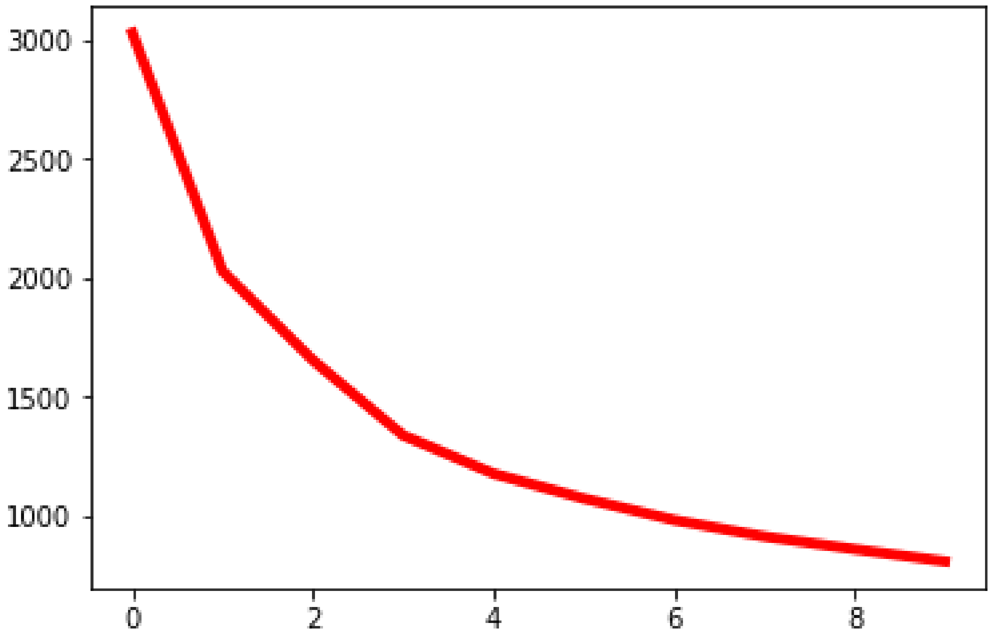


2 b and c:

```
In [47]: import scipy.linalg
         U,S,V=scipy.linalg.svd(X0,False)
         W=U.dot(np.diag(S));
         print(W.shape,V.shape)
```

```
(4916, 576) (576, 576)
```

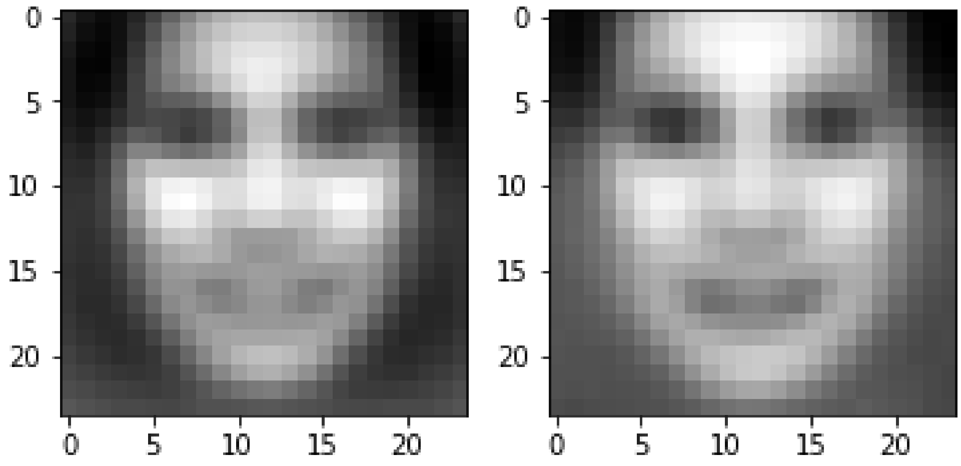
```
In [48]: err=[None]*10
         for k in range(10):
             Xhat0=W[:,:k].dot(V[:k,:])
             err[k]=((X0-Xhat0)**2).mean()
         plt.plot(range(10),err,'r-',linewidth=4);
```



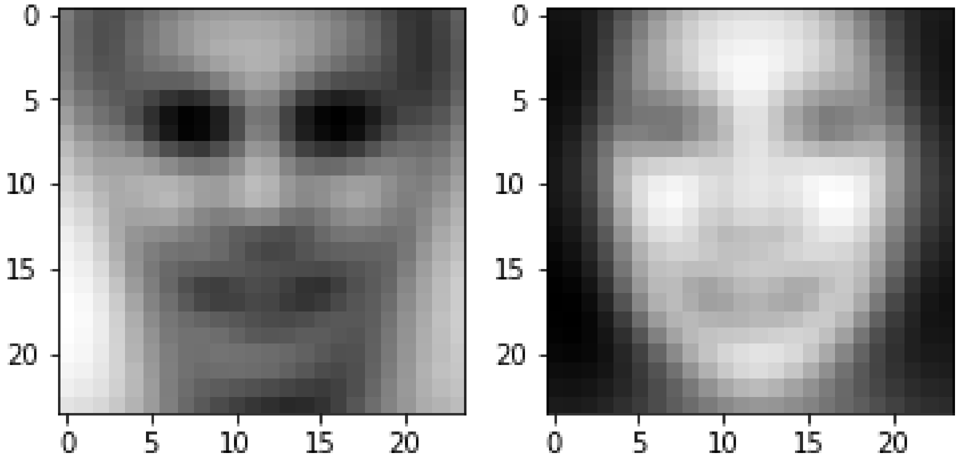
2c : First 3 principal dimensions of data:

```
In [49]: for k in range(3):
             alpha=2*np.median(np.abs(W[:,k]));
             im1=np.reshape(mu+alpha*V[k,:],(24,24));
             im2=np.reshape(mu-alpha*V[k,:],(24,24));
             plt.figure();
             f,(ax1,ax2)=plt.subplots(1,2);
             ax1.imshow(im1.T,cmap="gray");
             ax2.imshow(im2.T,cmap="gray");
```

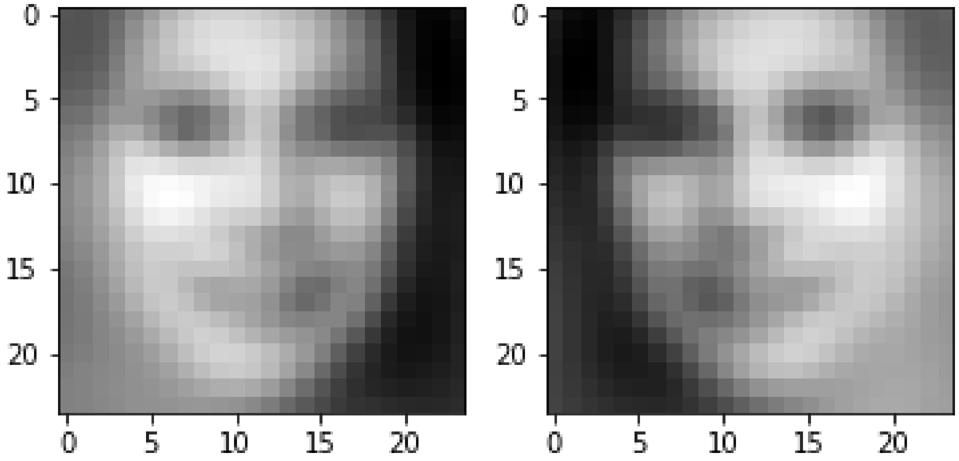
```
<Figure size 432x288 with 0 Axes>
```



```
<Figure size 432x288 with 0 Axes>
```



```
<Figure size 432x288 with 0 Axes>
```

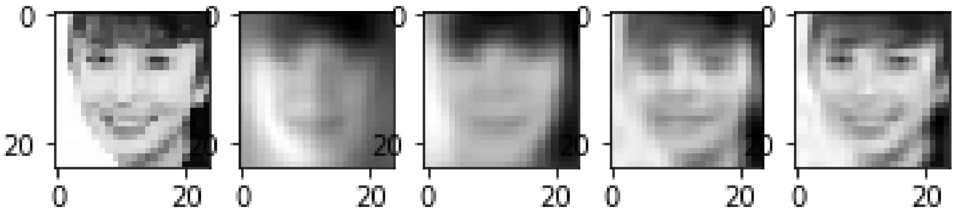


2e: Reconstruct 2 faces using first K principal directions

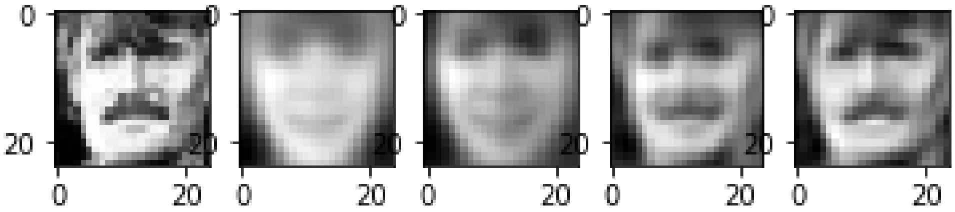
```
In [50]: for i in [24,25]:
             im=X[i,:];
             im=np.reshape(im,(24,24));
```

```
plt.figure()
f,ax=plt.subplots(1,5);
ax[0].imshow(im.T,cmap="gray");
for j,k in enumerate([5,10,50,100]):
    im=mu+W[i,0:k].dot(V[0:k,:]);
    im=np.reshape(im,(24,24));
    ax[j+1].imshow(im.T,cmap="gray");
```

```
<Figure size 432x288 with 0 Axes>
```

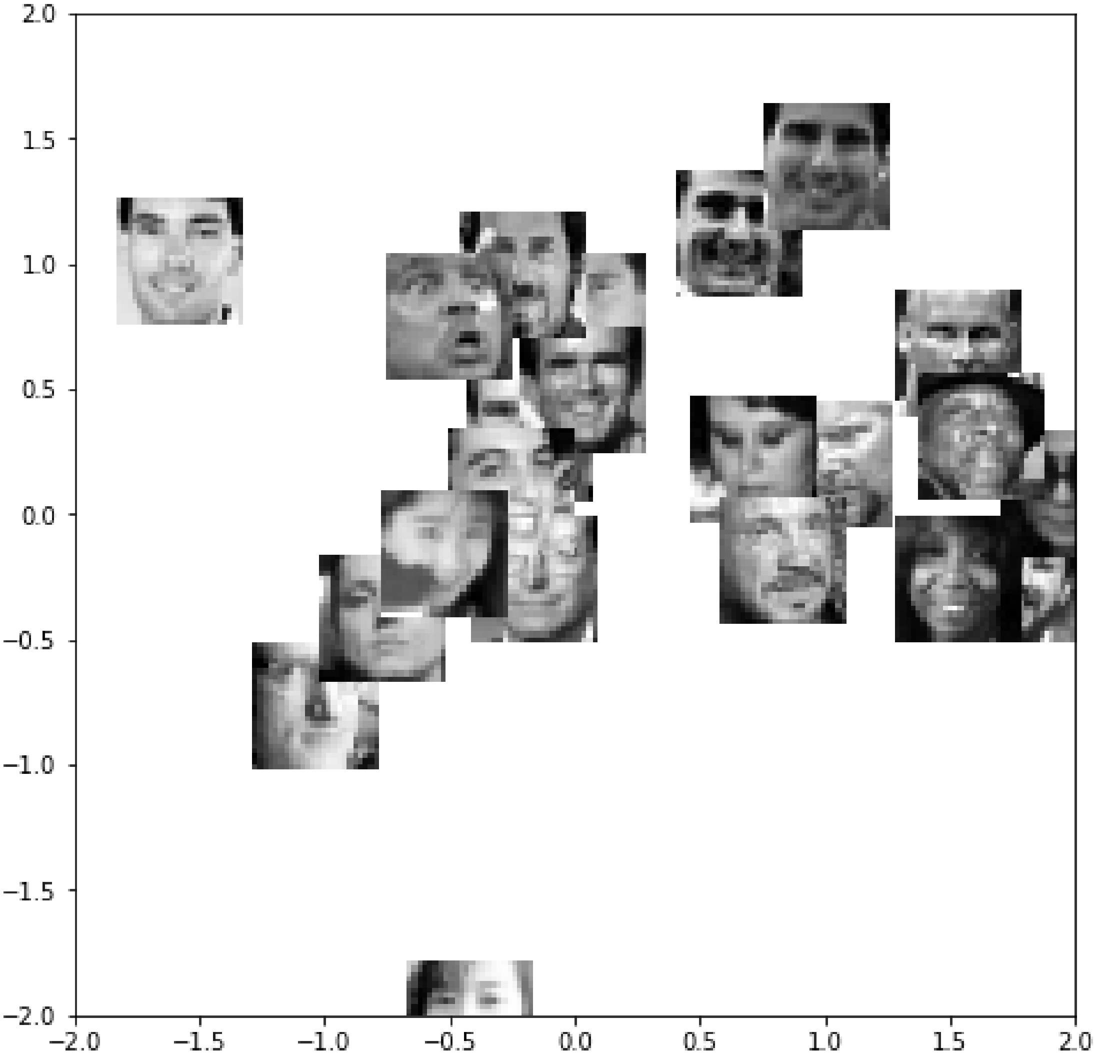


```
<Figure size 432x288 with 0 Axes>
```



2f:

```
In [51]: import mltools.transforms
         idx=np.floor(4916*np.random.rand(25));
         idx=idx.astype('int')
         plt.rcParams['figure.figsize']=(8.0,8.0)
         coord,params=ml.transforms.rescale(W[:,0:2])
         for i in idx:
             loc = (coord[i,0],coord[i,0]+0.5, coord[i,1],coord[i,1]+0.5)
             img = np.reshape( X[i,:], (24,24) ) # reshape to square
             plt.imshow( img.T , cmap="gray", extent=loc ) # draw each image
             plt.axis( (-2,2,-2,2) )
```


2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
−2.0
−1.5
−1.0
−0.5
0.0
0.5
1.0
1.5
2.0