178 HW5

March 11, 2020

0.0.1 Zhiyuan's Solution

[40]:

```
import numpy as np
import matplotlib.pyplot as plt
import mltools as ml
import scipy.linalg

np.random.seed(0)
%matplotlib inline
```

1 Problem 1: Clustering

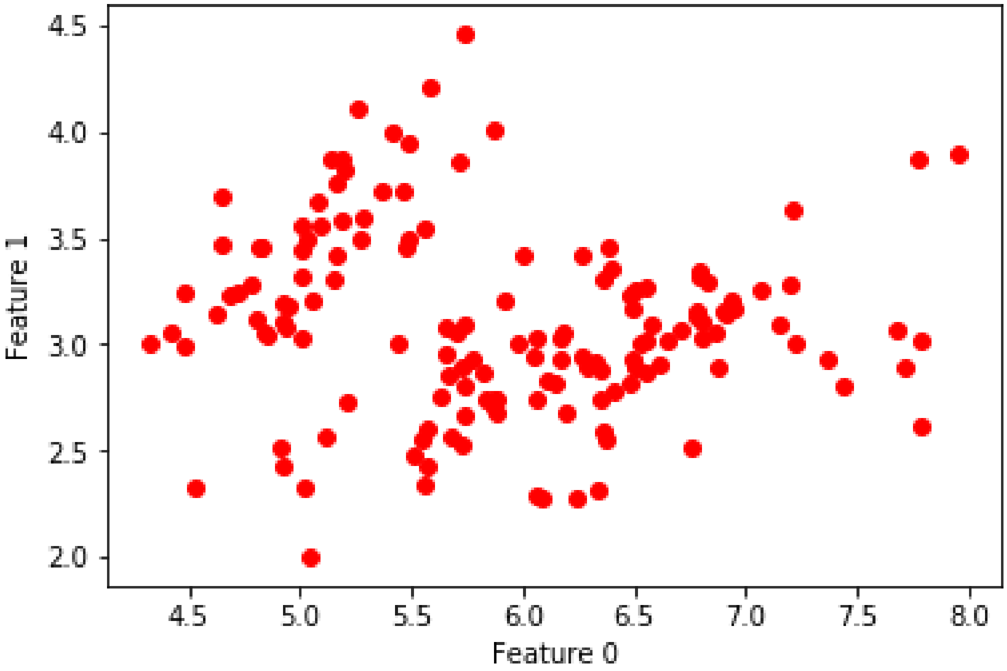
[5]:

```
iris = np.genfromtxt('data/iris.txt', delimiter=None)
```

1.1 Q1

[9]:

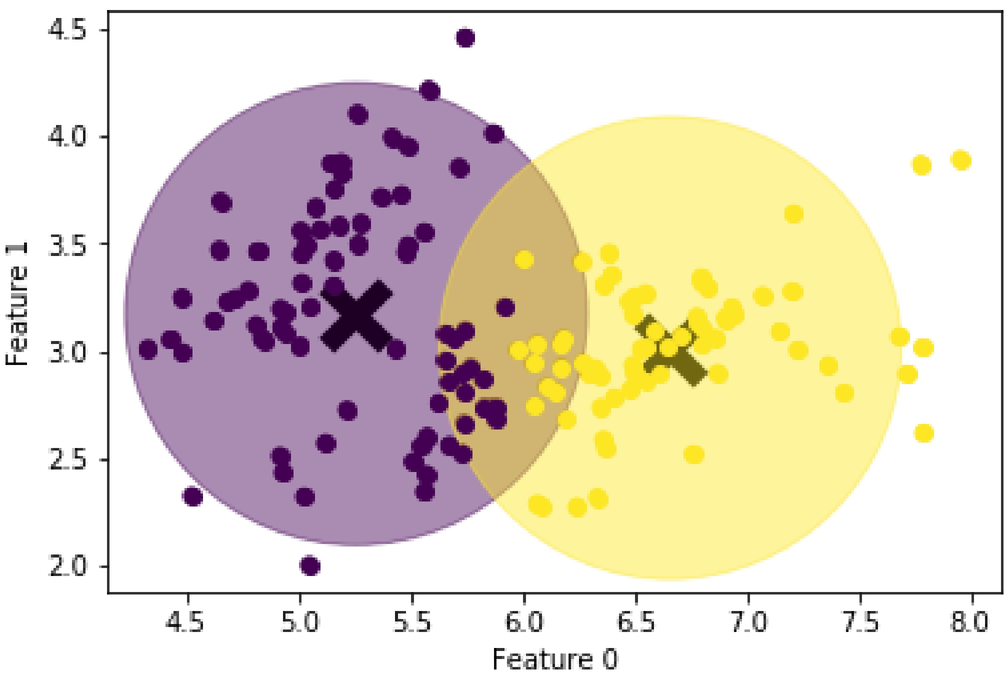
```
X = iris[:,0:2]

plt.scatter(X[:,0], X[:,1], color = 'r')
plt.xlabel('Feature 0')
plt.ylabel('Feature 1')
plt.show()
```



1.2 Q2

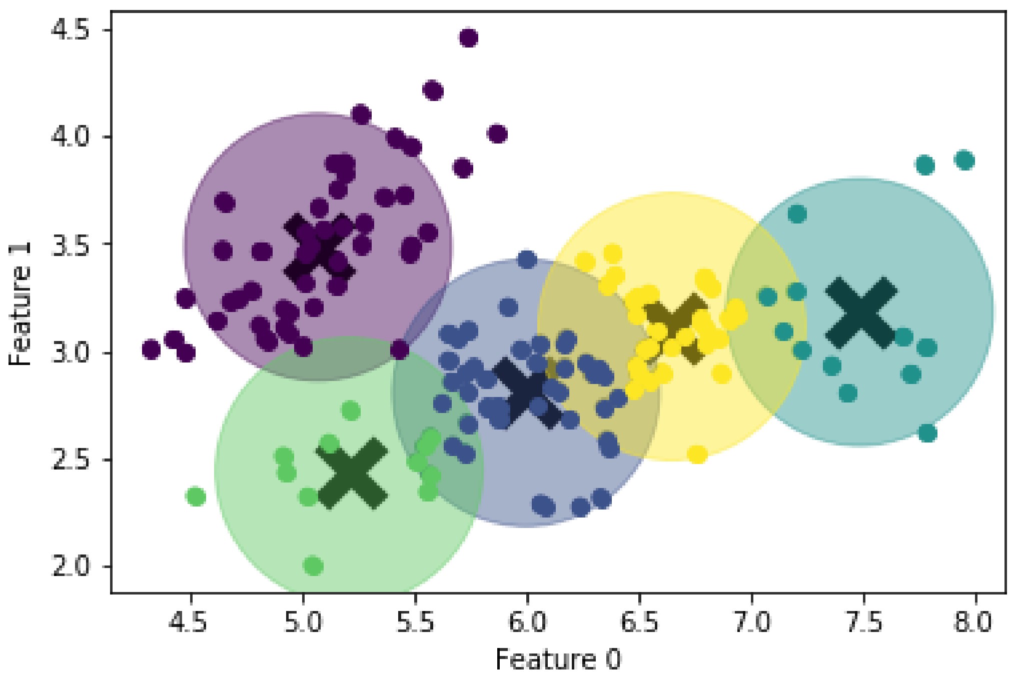
k = 2

[17]:
```
z, mu, ssd = ml.cluster.kmeans(X, K=2, init='k++', max_iter=100)
ml.plotClassify2D(None,X,z)

plt.scatter(X[:, 0], X[:, 1], c=z) # Plotting the data
plt.scatter(mu[:, 0], mu[:, 1], s=500, marker='x', facecolor='black', lw=8) #␣
 ↪Plotting the centroids
plt.scatter(mu[:, 0], mu[:, 1], s=30000, alpha=.45, c=np.unique(z)) # Lazy way␣
 ↪of plotting the clusters area :)

plt.xlabel('Feature 0')
plt.ylabel('Feature 1')
plt.show()
```



k = 5

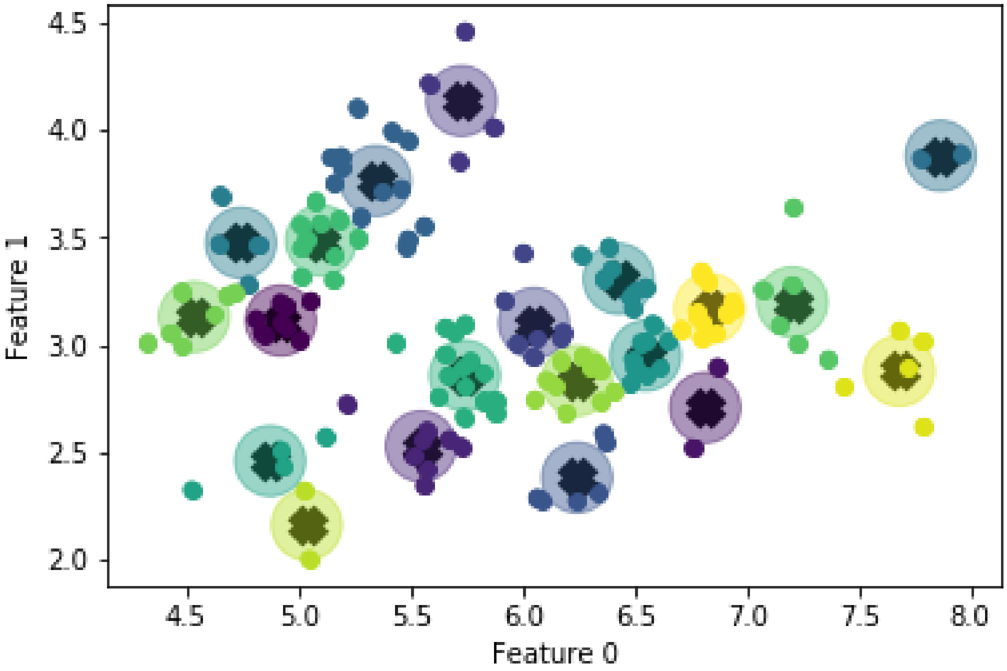
[19]:
```
z, mu, ssd = ml.cluster.kmeans(X, K=5, init='k++', max_iter=100)
ml.plotClassify2D(None,X,z)

plt.scatter(X[:, 0], X[:, 1], c=z) # Plotting the data
plt.scatter(mu[:, 0], mu[:, 1], s=500, marker='x', facecolor='black', lw=8) #␣
 ↪Plotting the centroids
plt.scatter(mu[:, 0], mu[:, 1], s=10000, alpha=.45, c=np.unique(z)) # Lazy way␣
 ↪of plotting the clusters area :)

plt.xlabel('Feature 0')
plt.ylabel('Feature 1')
plt.show()
```



k = 20

[23]:

```
z, mu, ssd = ml.cluster.kmeans(X, K=20, init='k++', max_iter=100)
ml.plotClassify2D(None,X,z)

plt.scatter(X[:, 0], X[:, 1], c=z) # Plotting the data
plt.scatter(mu[:, 0], mu[:, 1], s=100, marker='x', facecolor='black', lw=8) #␣
 ↪Plotting the centroids
plt.scatter(mu[:, 0], mu[:, 1], s=700, alpha=.45, c=np.unique(z)) # Lazy way of␣
 ↪plotting the clusters area :)

plt.xlabel('Feature 0')
plt.ylabel('Feature 1')
plt.show()
```

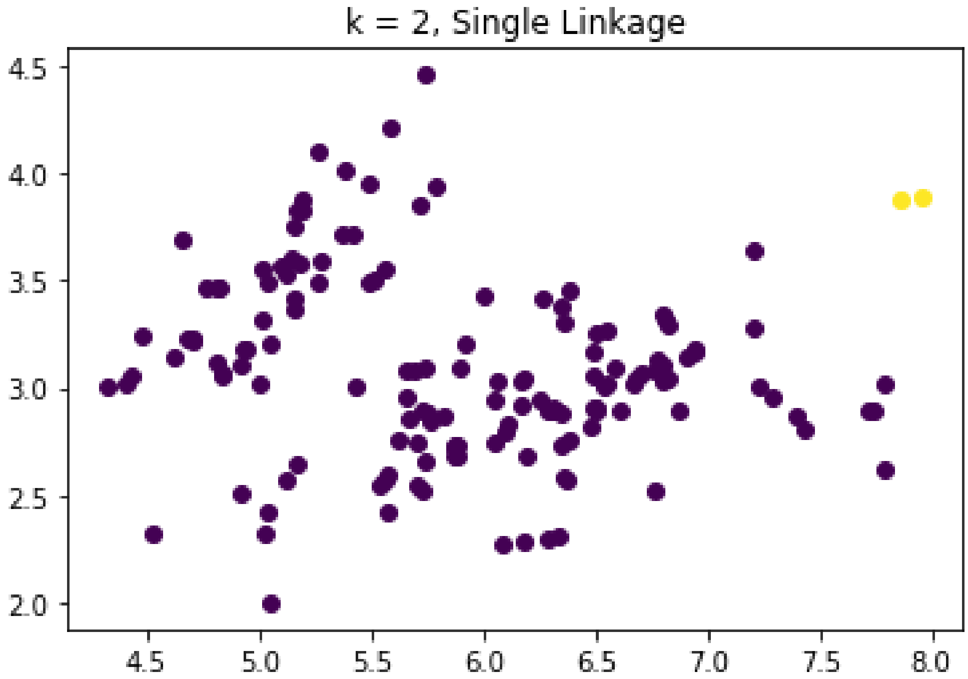


1.3 Q3

k = 2

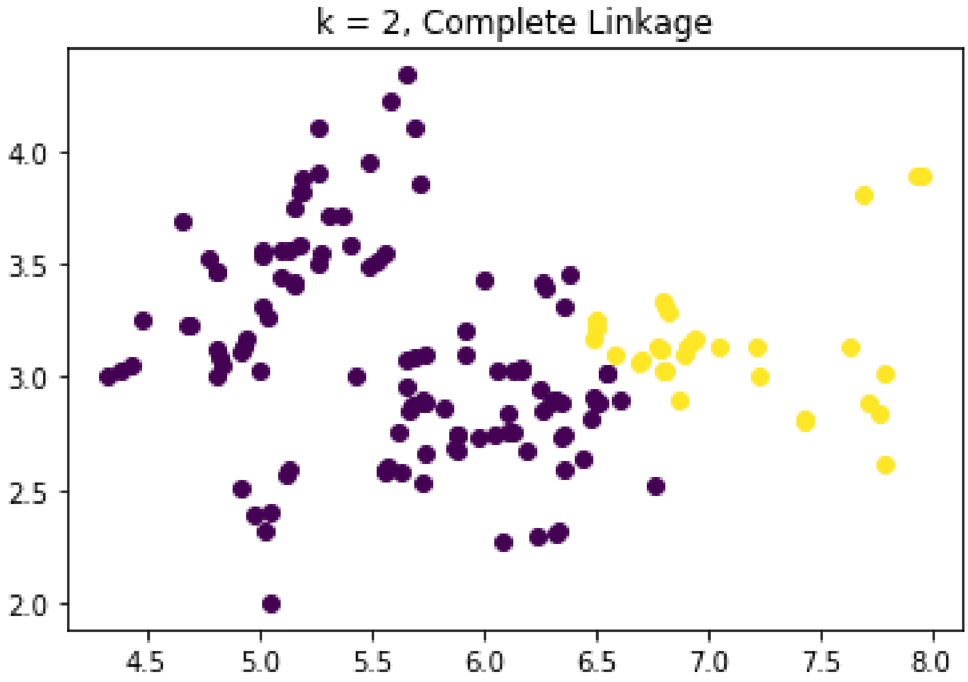
[24]:
```
z, c = ml.cluster.agglomerative(X, 2, method='min')
ml.plotClassify2D(None,X,z)

plt.title('k = 2, Single Linkage')
plt.show
```

[24]:
```
<function matplotlib.pyplot.show(*args, **kw)>
```



```
[26]: z, c = ml.cluster.agglomerative(X, 2, method='max')
      ml.plotClassify2D(None,X,z)

      plt.title('k = 2, Complete Linkage')
      plt.show
```

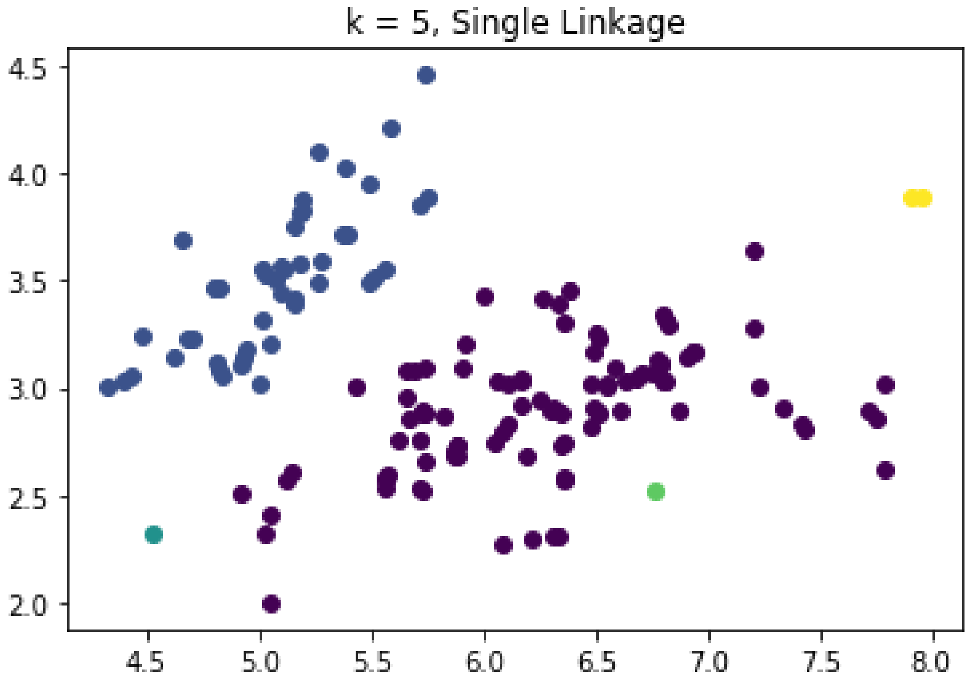
```
[26]: <function matplotlib.pyplot.show(*args, **kw)>
```



k = 5

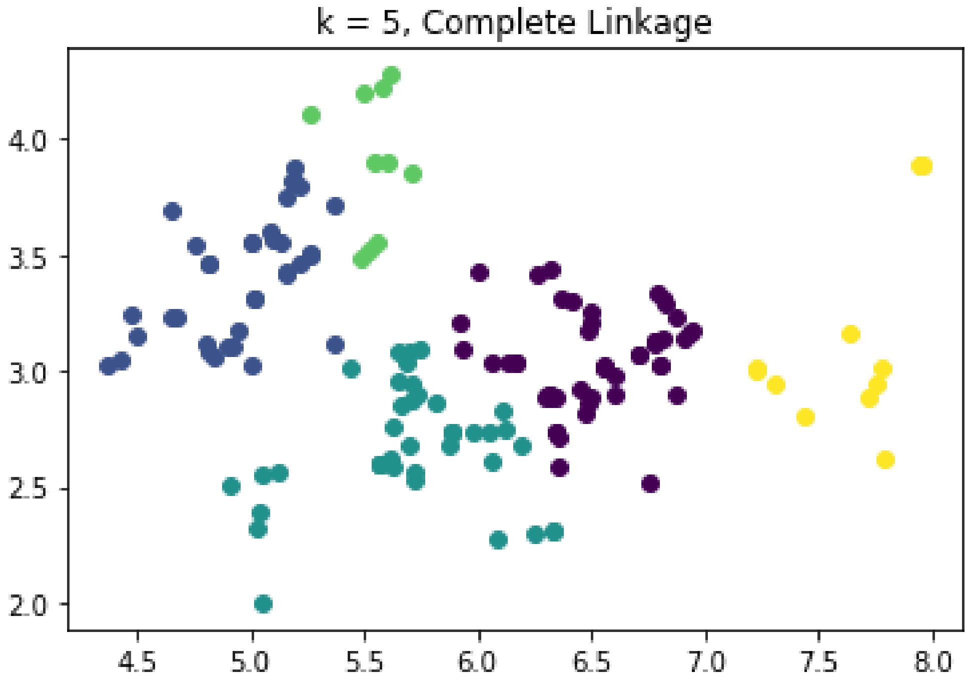
[25]:
```
z, c = ml.cluster.agglomerative(X, 5, method='min')
ml.plotClassify2D(None,X,z)

plt.title('k = 5, Single Linkage')
plt.show
```

[25]:
```
<function matplotlib.pyplot.show(*args, **kw)>
```



[29]:
```
z, c = ml.cluster.agglomerative(X, 5, method='max')
ml.plotClassify2D(None,X,z)

plt.title('k = 5, Complete Linkage')
plt.show
```

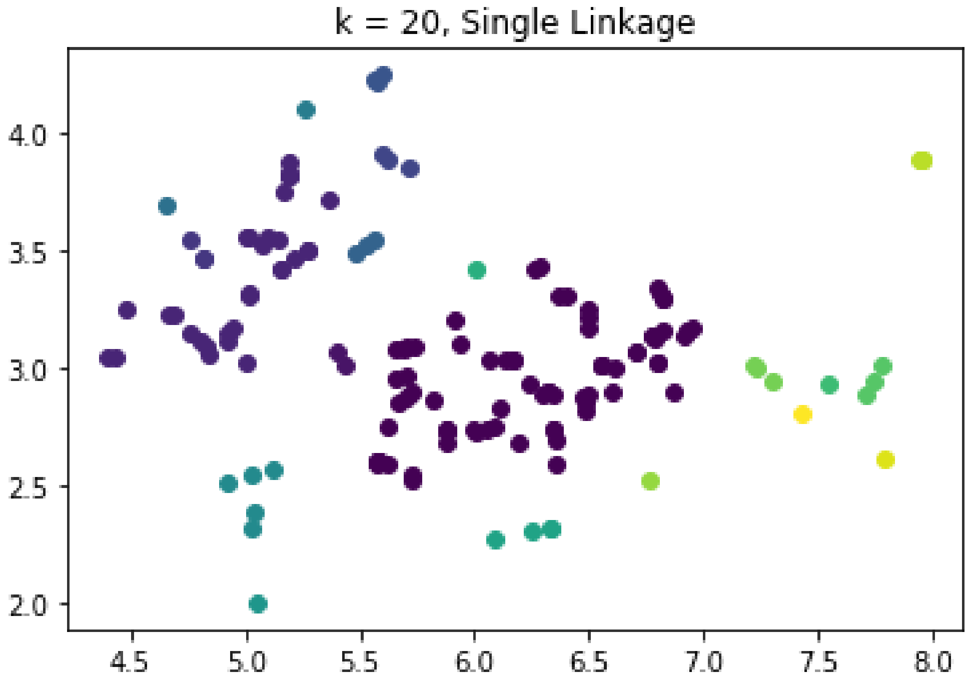
[29]:
```
<function matplotlib.pyplot.show(*args, **kw)>
```



k = 20

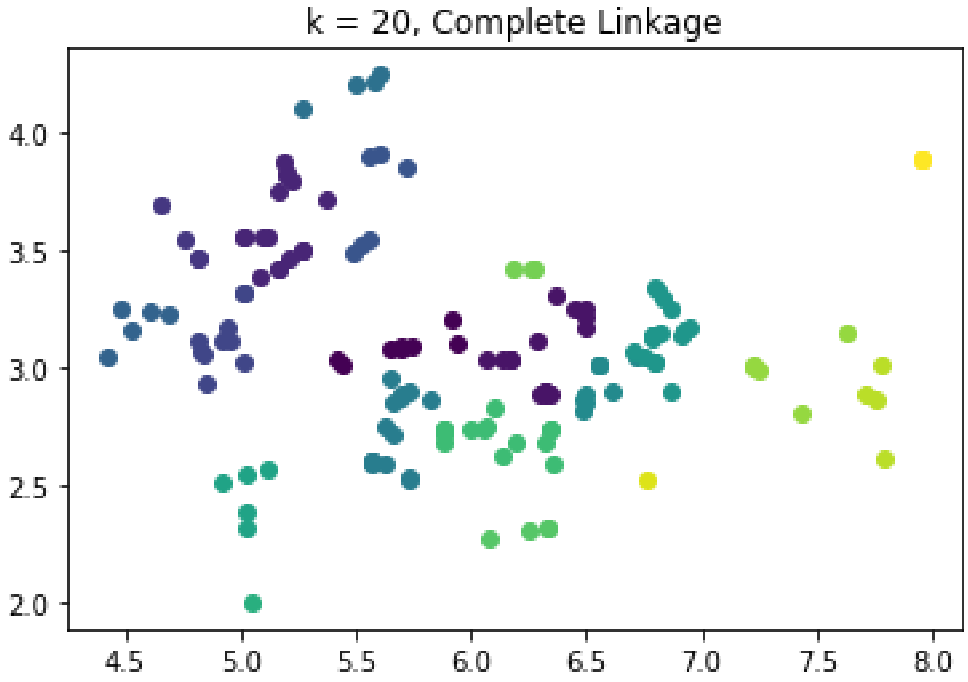
[30]:
```
z, c = ml.cluster.agglomerative(X, 20, method='min')
ml.plotClassify2D(None,X,z)

plt.title('k = 20, Single Linkage')
plt.show
```

[30]:
```
<function matplotlib.pyplot.show(*args, **kw)>
```



[31]:
```
z, c = ml.cluster.agglomerative(X, 20, method='max')
ml.plotClassify2D(None,X,z)

plt.title('k = 20, Complete Linkage')
plt.show
```

[31]:
```
<function matplotlib.pyplot.show(*args, **kw)>
```



1.4 Q4

In both kinds of clustering, points are grouped into catagories. In each catagory, the points are relatively close to each other.

However, in agglomerative clustering, there are some clusters with extremely small number of points and some with many points, while in K-means, each cluster has roughly the same size.

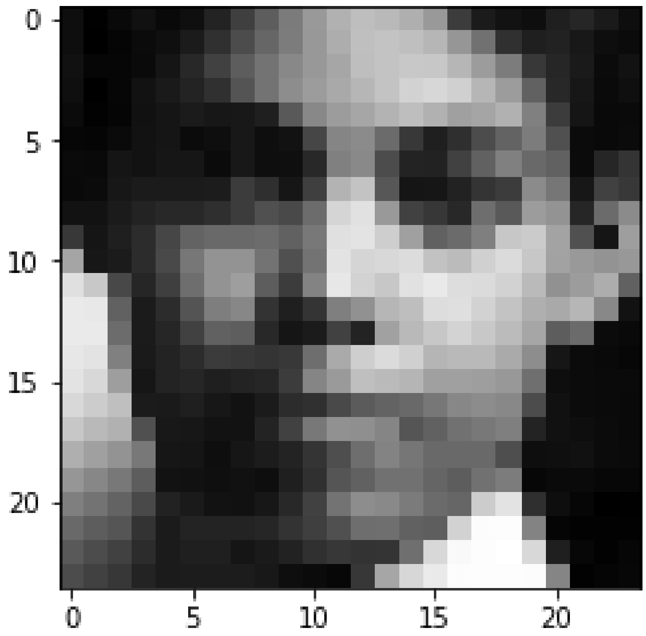
2 Problem 2: EigenFaces

2.1 Q1

```
[38]: mu = np.mean(X)
X0 = X - mu

print(X0.shape)

X = np.genfromtxt("data/faces.txt", delimiter=None) # load face dataset
plt.figure() # pick a data point i for display
img = np.reshape(X0[5,:],(24,24)) # convert vectorized data to 24x24 image␣
 ↪patches
plt.imshow(img.T , cmap="gray") # display image patch; you may have to squint
```

```
(4916, 576)
```

```
[38]: <matplotlib.image.AxesImage at 0x11c5b9fd0>
```



2.2 Q2

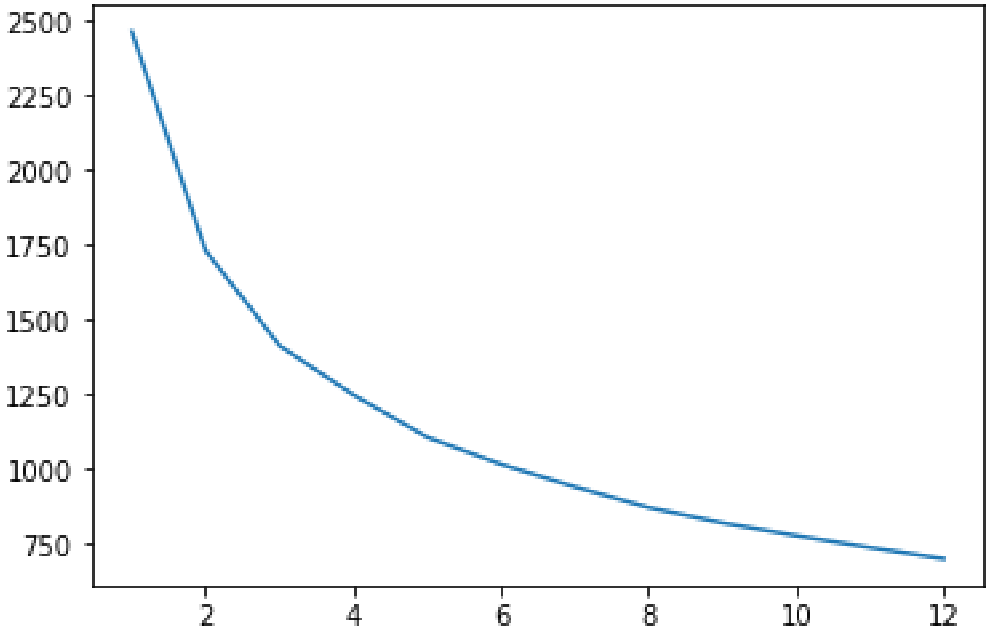
```
[41]: U, S, V = scipy.linalg.svd(X0, full_matrices = False)
      W = U.dot(np.diag(S))

      print(W.shape)
      print(V.shape)
```

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

2.3 Q3

```
[46]: MSE = list()
      for K in range(1, 13):
          X0hat = W[:,:K].dot(V[:K,:])
          MSE.append(np.mean((X0 - X0hat)**2))

      xaxis = range(1, 13)

      plt.plot(xaxis, MSE)

      print(MSE)
```

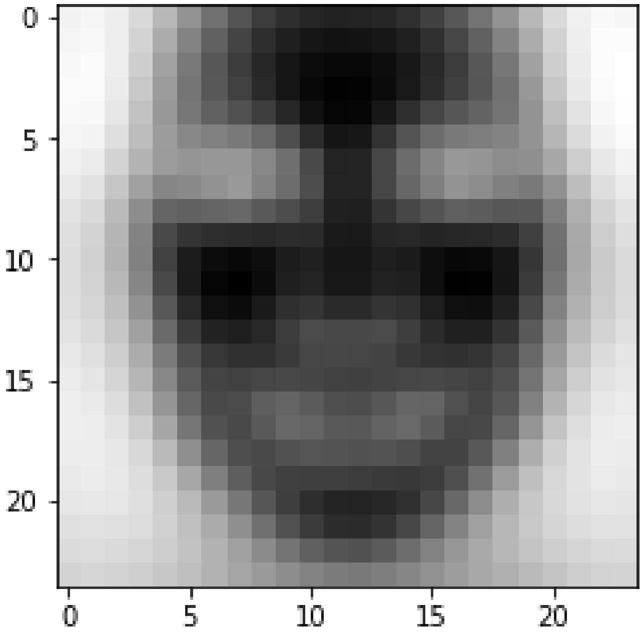
```
[2465.915252687558, 1731.142532445829, 1413.0932957824566, 1248.4288215715092,
1106.5645688183095, 1015.8604245366287, 940.218724905595, 870.8898980704487,
819.5686398124661, 776.5783778336007, 736.6968053471978, 699.130487149125]
```

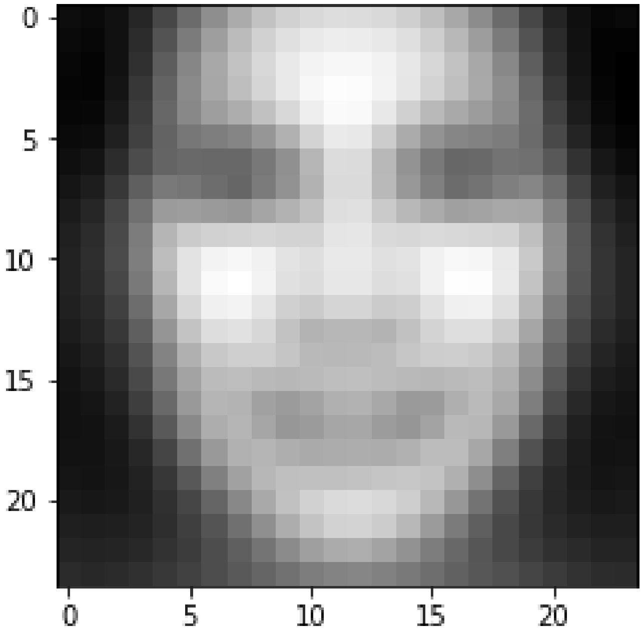


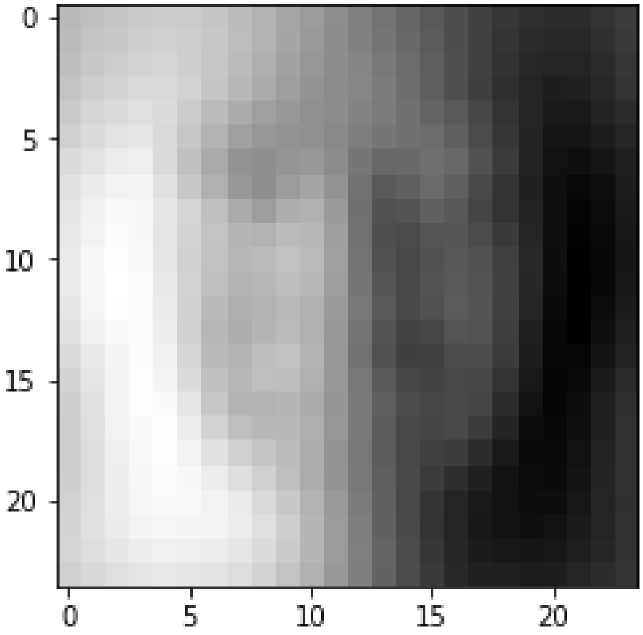
2.4 Q4

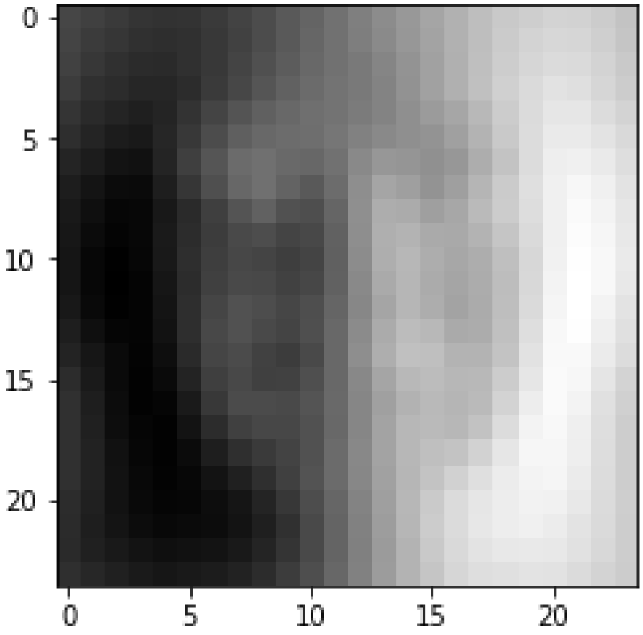
[50]:

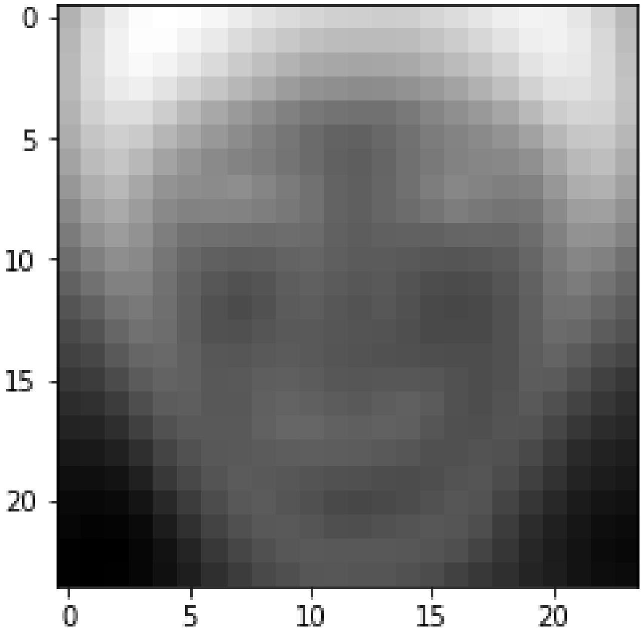
```
for j in range(1, 4):
    alpha = 2 * np.median(np.abs(W[:,j]))
    img1 = np.reshape((mu + alpha*V[j,:]), (24,24))
    img2 = np.reshape((mu - alpha*V[j,:]), (24,24))

    plt.imshow(img1.T , cmap="gray")
    plt.show()
    plt.imshow(img2.T , cmap="gray")
    plt.show()
```

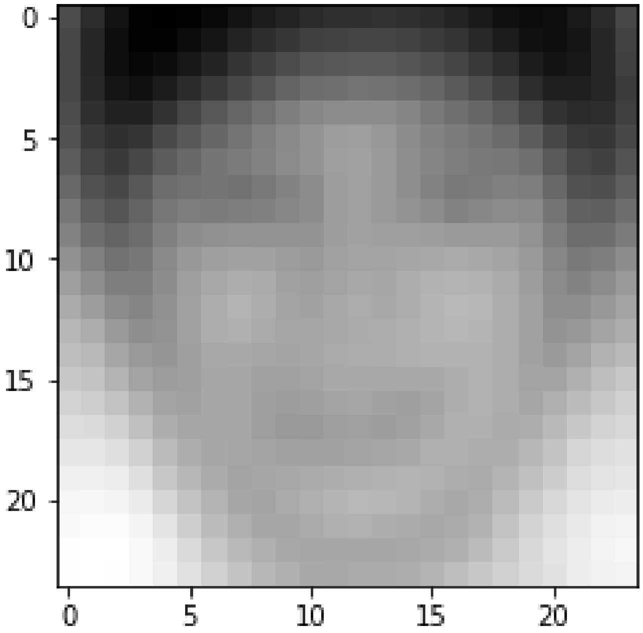

0
5
10
15
20
0
5
10
15
20


0
5
10
15
20
0
5
10
15
20


0
5
10
15
20
0
5
10
15
20


0
5
10
15
20
0
5
10
15
20

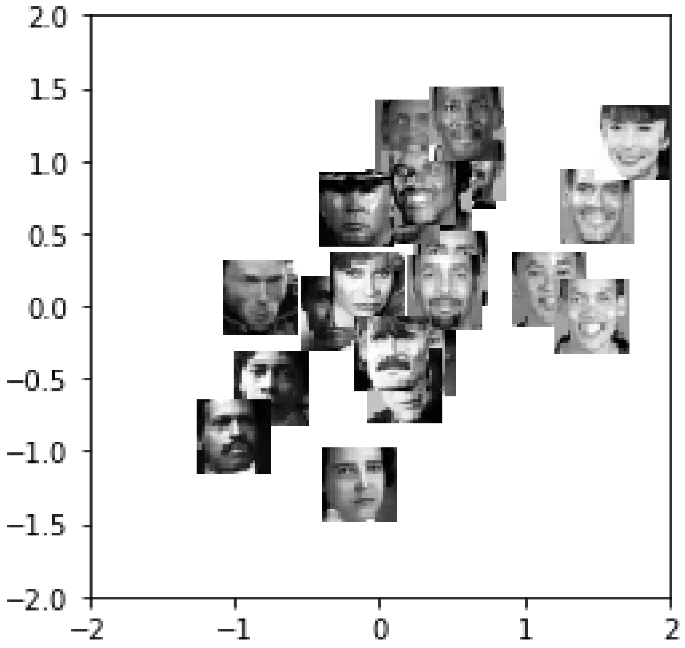

0
5
10
15
20
0
5
10
15
20


0
5
10
15
20
0
5
10
15
20

2.5 Q6

```
[51]: idx = range(1, 26) # pick some data (randomly or otherwise); an array of␣
       ↪integer indices

      import mltools.transforms
      coord,params = ml.transforms.rescale( W[:,0:2] ) # normalize scale of "W"␣
       ↪locations
      plt.figure(); plt.hold(True); # you may need this for pyplot
      for i in idx: # compute where to place image (scaled W values) & size
          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) ) # set axis to a reasonable scale
```

```
/opt/anaconda3/lib/python3.7/site-packages/ipykernel_launcher.py:5:
MatplotlibDeprecationWarning: pyplot.hold is deprecated.
    Future behavior will be consistent with the long-time default:
    plot commands add elements without first clearing the
    Axes and/or Figure.
  """
/opt/anaconda3/lib/python3.7/site-packages/matplotlib/__init__.py:911:
MatplotlibDeprecationWarning: axes.hold is deprecated. Please remove it from
your matplotlibrc and/or style files.
  mplDeprecation)
/opt/anaconda3/lib/python3.7/site-packages/matplotlib/rcsetup.py:156:
MatplotlibDeprecationWarning: axes.hold is deprecated, will be removed in 3.0
  mplDeprecation)
```



I did this homework alone.