Machine Intelligence 2

Exercise 10

K-means, hierarchical, and soft clustering

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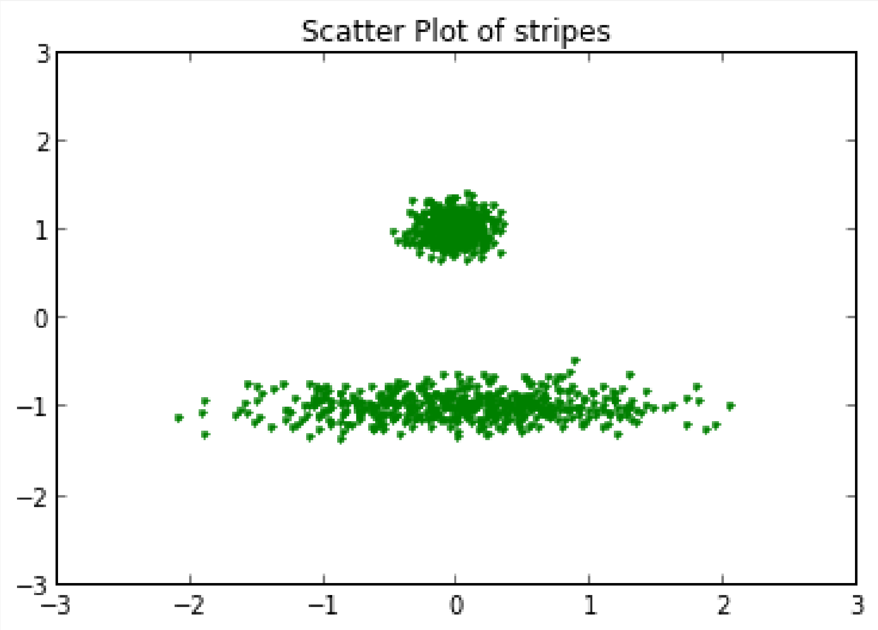
1 10.1 K-means and hierarchical clustering

```
#function
from numpy import *
import matplotlib
import matplotlib.pyplot as plt
import cluster
from mpl_toolkits.mplot3d import Axes3D

def plot3dScatter(X,Y,Z,title,c):
    fig = plt.figure()
    ax = Axes3D(fig)
    ax.plot(X,Y,Z,c)
    ax.set_title(title)
    plt.show()

def plotScatter(X,Y,title,c,ran):
    fig = plt.figure()
    ax = fig.add_subplot(111)
    ax.axis([-ran,ran,-ran,ran])
    ax.plot(X,Y,c+'.')
    ax.set_title(title)
    plt.show()

def plotScatter2(X,Y,title):
    fig = plt.figure()
    ax = fig.add_subplot(111)
    for i in range (len(X)):
        ax.plot(X[i],Y[i],'g.')
    ax.set_title(title)
    plt.show()

def plotCluster(clusters,colors,title,ran):
    fig = plt.figure()
    ax = fig.add_subplot(111)
    ax.axis([-ran,ran,-ran,ran])
    for i in range (len(clusters)):
        for j in range (len(clusters[i])):
            ax.plot(clusters[i][j][0],clusters[i][j][1],colors[i]+'.')
    ax.set_title(title)
    plt.show()


def plotCluster3d(X,Y,Z,result,colors,title):
    fig = plt.figure()
    ax = Axes3D(fig)
    for i in range (len(X)):
        ax.scatter(X[i],Y[i],Z[i],c=colors[result[i]-1] )
    ax.set_title(title)
    plt.show()
```

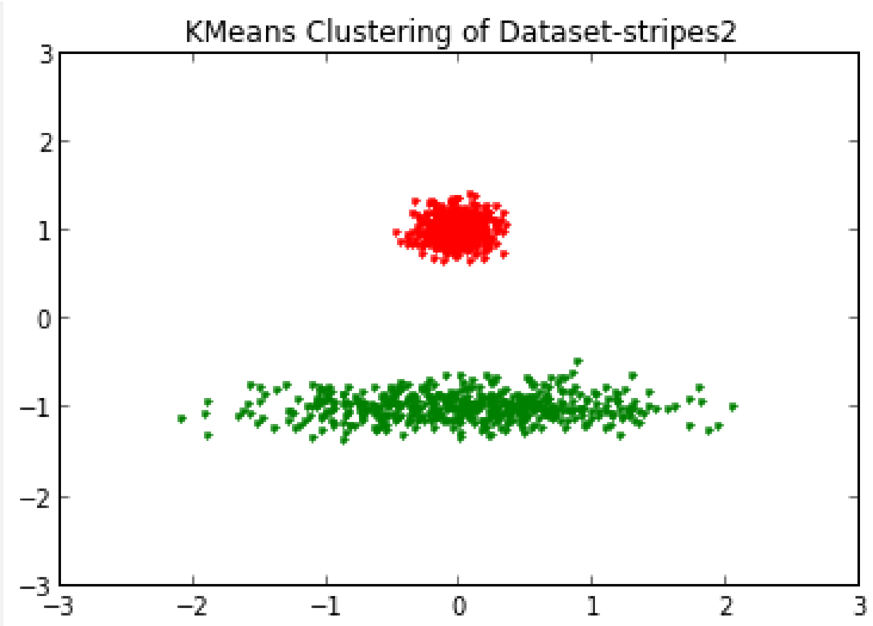
1.1 stripes2

```
data = loadtxt("clusters/stripes2.csv",skiprows=1,delimiter=",",usecols=(1,2))
X = data[:,0]
Y = data[:,1]
plotScatter(X,Y,"Scatter Plot of stripes",'g',3)

kdata = [0 for i in range (len(X))]
for i in range (len(X)):
    kdata[i] = (X[i],Y[i])
```



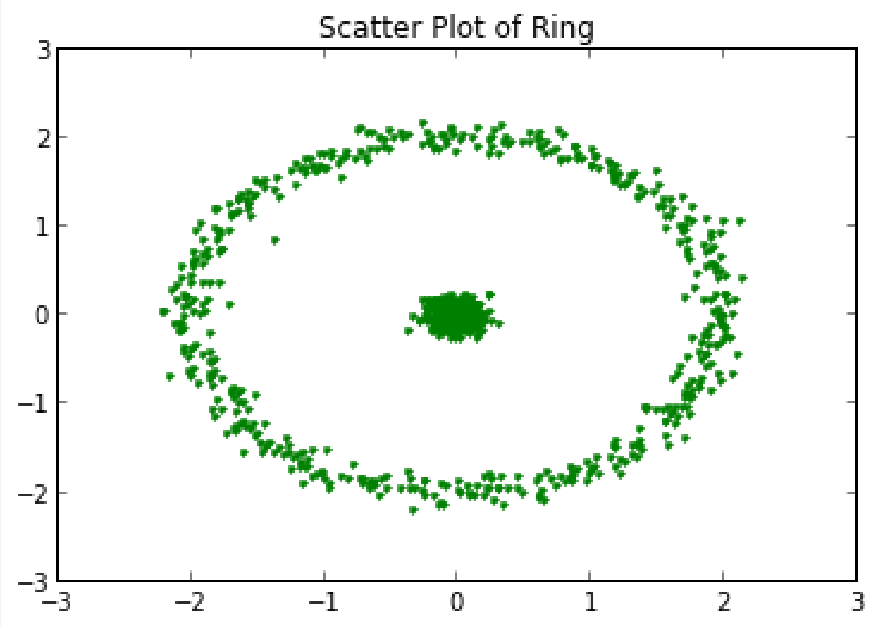

```
#Kmeans
cl = cluster.KMeansClustering(kdata)
result = cl.getclusters(2)
```

```
colors = ['r','g','b','c','m']
plotCluster(result,colors,"KMeans Clustering of Dataset-stripes2",3)
```



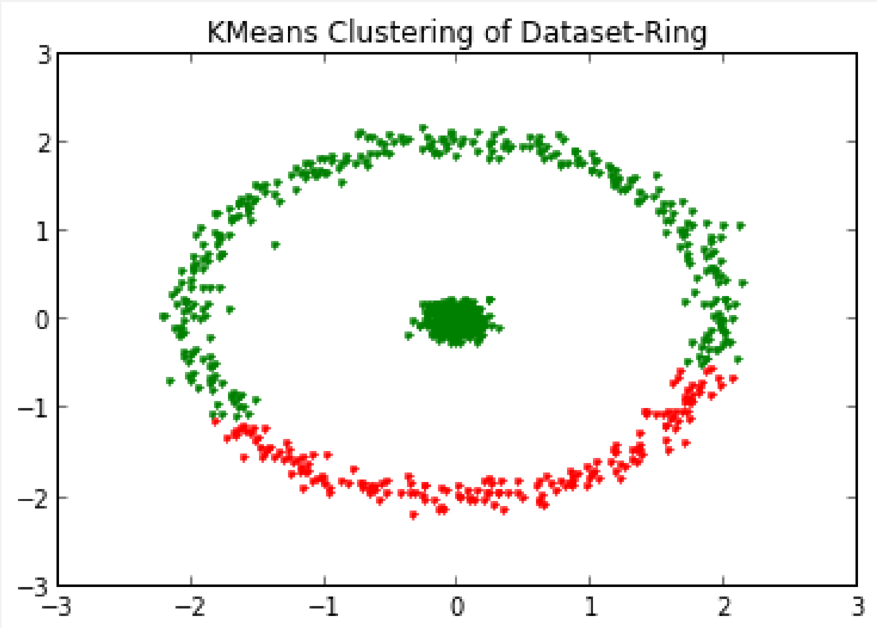
1.2 Ring

```
data = loadtxt("clusters/ring.csv",skiprows=1,delimiter=",",usecols=(1,2))
X = data[:,0]
Y = data[:,1]
plotScatter(X,Y,"Scatter Plot of Ring",'g',3)

kdata = [0 for i in range (len(X))]
for i in range (len(X)):
    kdata[i] = (X[i],Y[i])
```



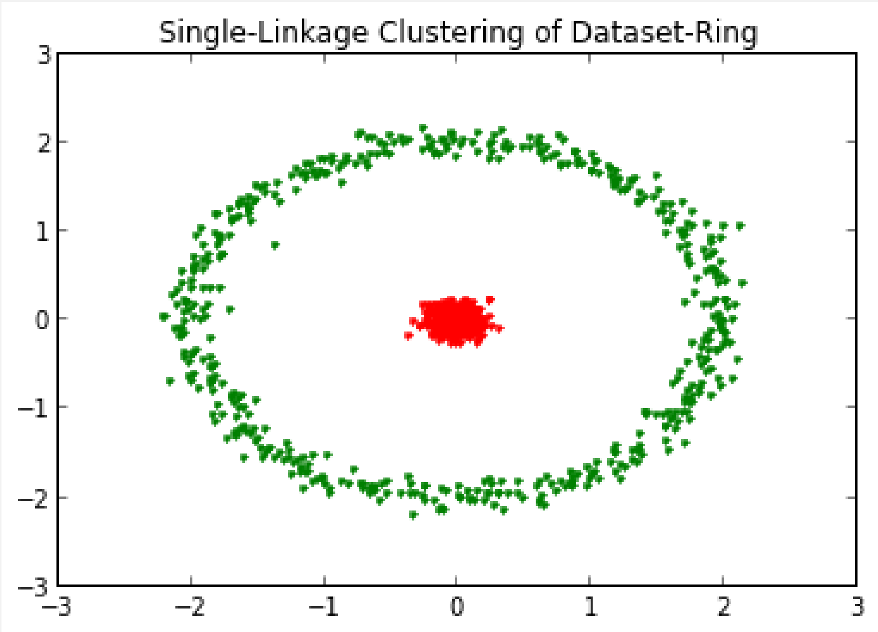

```
#Kmeans
cl = cluster.KMeansClustering(kdata)
result = cl.getclusters(2)
```

```
colors = ['r','g','b','c','m']
plotCluster(result,colors,"KMeans Clustering of Dataset-Ring",3)
```



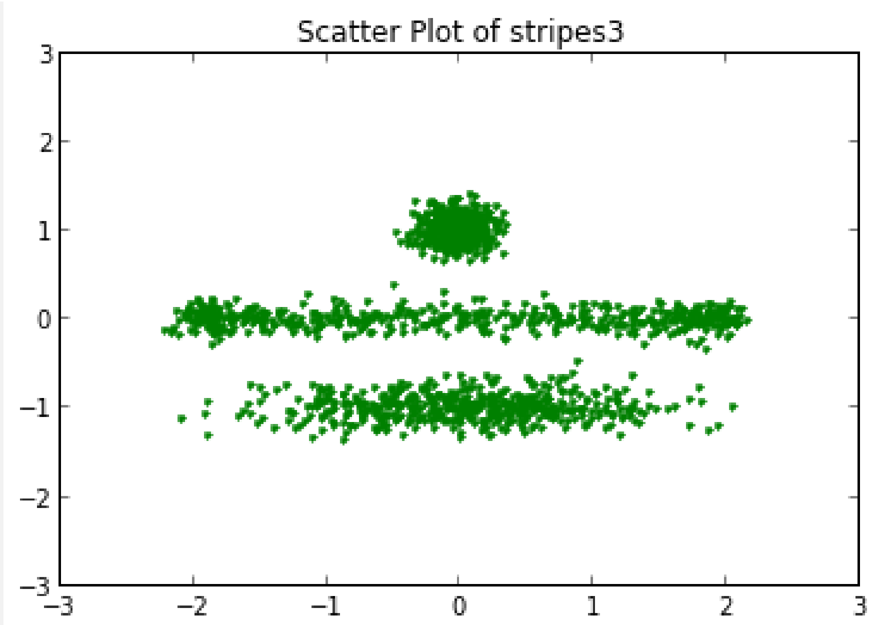
```
#Single-Linkage
cl = cluster.HierarchicalClustering(kdata, lambda (x1,y1),(x2,y2): math.sqrt((x1-x2)
    **2+(y1-y2)**2),'single' )
result = cl.getlevel(1)
```

```
colors = ['r','g','b','c','m']
plotCluster(result,colors,"Single-Linkage Clustering of Dataset-Ring",3)
```



1.3 stripes3

```
data = loadtxt("clusters/stripes3.csv",skiprows=1,delimiter=",",usecols=(1,2))
X = data[:,0]
Y = data[:,1]
plotScatter(X,Y,"Scatter Plot of stripes3",'g',3)

kdata = [0 for i in range (len(X))]
for i in range (len(X)):
    kdata[i] = (X[i],Y[i])
```

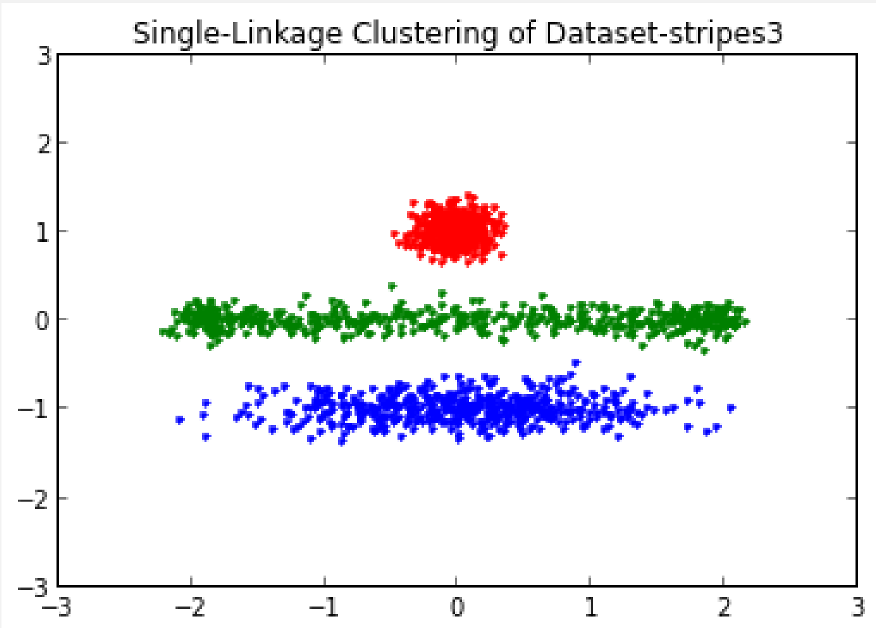



```
#Kmeans
cl = cluster.KMeansClustering(kdata)
result = cl.getclusters(2)
```

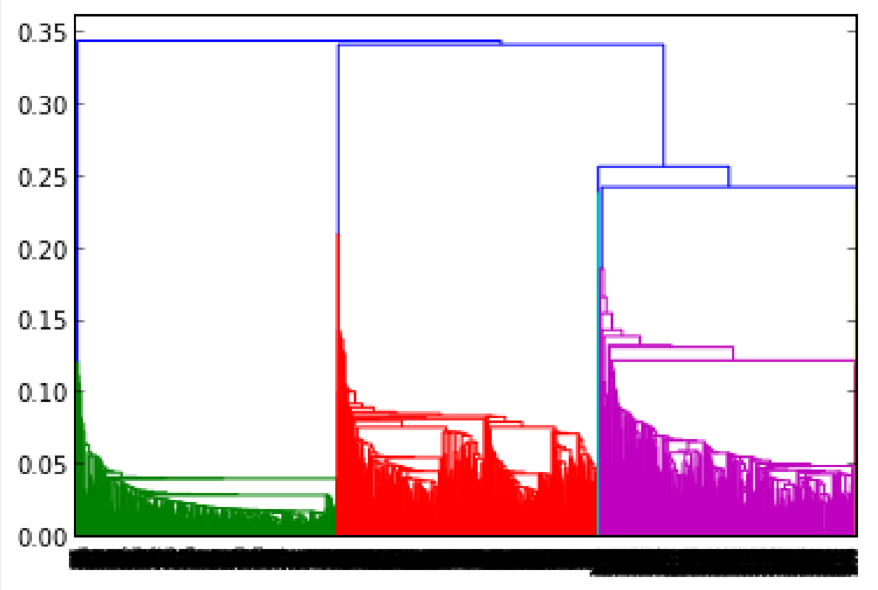
```
colors = ['r','g','b','c','m']
plotCluster(result,colors,"KMeans Clustering of Dataset-stripes3",3)
```

```
#Single-Linkage
cl = cluster.HierarchicalClustering(kdata, lambda (x1,y1),(x2,y2): math.sqrt((x1-x2)
    **2+(y1-y2)**2),'single' )
result = cl.getlevel(0.3)
```

```
colors = ['r','g','b','c','m']
plotCluster(result,colors,"Single-Linkage Clustering of Dataset-stripes3",3)
```

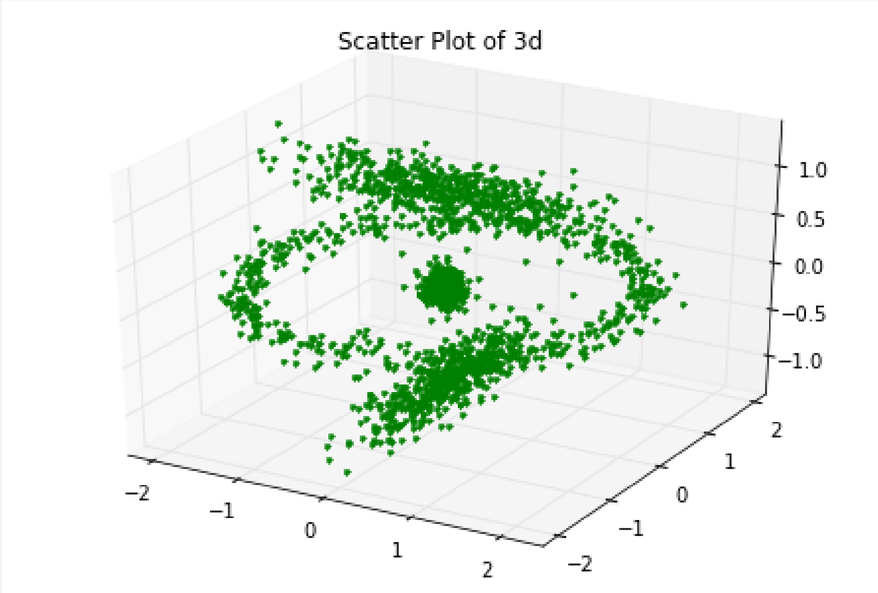



```
#linkage
import scipy.cluster.hierarchy as ch

kdata = [[0 for j in range (2)] for i in range (len(X))]
for i in range (len(X)):
    kdata[i][0] = X[i]
    kdata[i][1] = Y[i]

dis = scipy.spatial.distance.pdist(matrix(kdata))

linkresult = ch.linkage(dis)
den = ch.dendrogram(linkresult,get_leaves=False,show_leaf_counts=False)
```

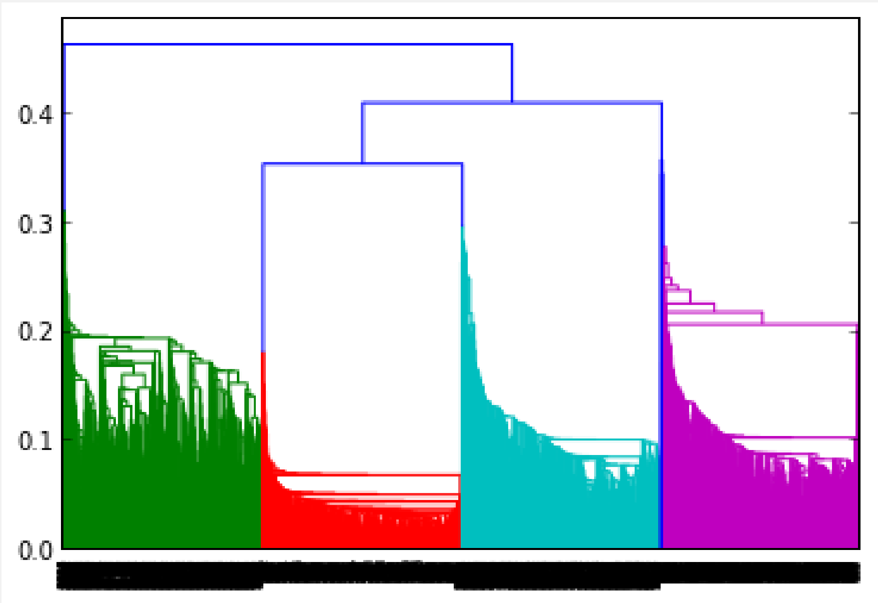


1.4 3d

```
data = loadtxt("clusters/3d.csv",skiprows=1,delimiter=",",usecols=(1,2,3))
X = data[:,0]
Y = data[:,1]
Z = data[:,2]
plot3dScatter(X,Y,Z,"Scatter Plot of 3d",'g.')

kdata = [0 for i in range (len(X))]
for i in range (len(X)):
    kdata[i] = (X[i],Y[i],Z[i])
```

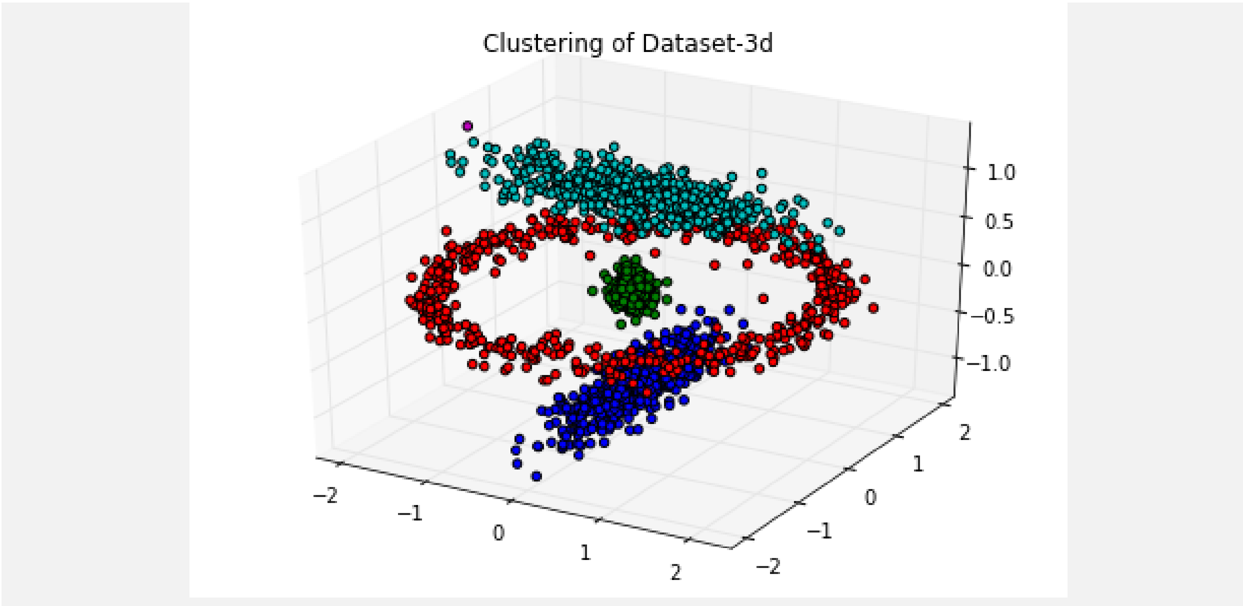


```
#linkage
import scipy.cluster.hierarchy as ch

hdata = [[0 for j in range (3)] for i in range (len(X))]
for i in range (len(X)):
    hdata[i][0] = X[i]
    hdata[i][1] = Y[i]
    hdata[i][2] = Z[i]

dis = scipy.spatial.distance.pdist(matrix(hdata))

linkresult = ch.linkage(dis)
den = ch.dendrogram(linkresult,get_leaves=False,show_leaf_counts=False)
```




```
R = ch.fcluster(linkresult,t=0.35,criterion='distance')
```

```
colors = ['r','g','b','c','m']
plotCluster3d(X,Y,Z,R,colors,"Clustering of Dataset-3d")
```



2 10.2 Soft K-means Clustering

```
#init W
def init_w(k,rSeed):
    random.seed(rSeed)
    W_init = [[0 for j in range(2)] for i in range(k)]
    for p in range(k):
        W_init[p][0] = random.random() * 6 - 3
        W_init[p][1] = random.random() * 6 -3
    return W_init
```

```
#soft-Kmeans
def kmeans_soft(X,Y,k,gamma,W_init,beta0,ita,betaf):
    beta = beta0
    W = [[ W_init[i][j] for j in range (len(W_init[0])) ] for i in range (len(W_init)) ]
    W_new = [[ W_init[i][j] for j in range (len(W_init[0])) ] for i in range (len(W_init)
        )]
    m = [[0 for j in range(k)] for i in range(len(X))]

    while True:

        end = False
        while True:
            for alpha in range (len(X)):
                tmpSum = 0.
                for q in range (k):
                    tmpSum += math.exp(-beta/2 * ( (X[alpha] - W[q][0])**2 + (Y[alpha] - W
                        [q][1])**2 ) )
                for p in range (k):
                    m[alpha][p] = math.exp(-beta/2 * ( (X[alpha] - W[p][0])**2 + (Y[alpha]
```

```
                    - W[p][1])**2 ) ) / tmpSum
          for p in range (k):
             mx_sum = 0.
             my_sum = 0.
             m_sum = 0.
             for alpha in range (len(X)):
                mx_sum += m[alpha][p] * X[alpha]
                my_sum += m[alpha][p] * Y[alpha]
                m_sum += m[alpha][p]
             W_new[p][0] = mx_sum / m_sum
             W_new[p][1] = my_sum / m_sum

          count = 0
          for q in range(k):
             if( math.sqrt( (W_new[q][0] - W[q][0])**2 + (W_new[q][1] - W[q][1])**2 ) <
                 gamma):
                count += 1
          if(count == k):
             end = True

          W = W_new[:][:]

          if (end):
             break

       beta = ita * beta
       if(beta > betaf):
          break

   return W,m
```

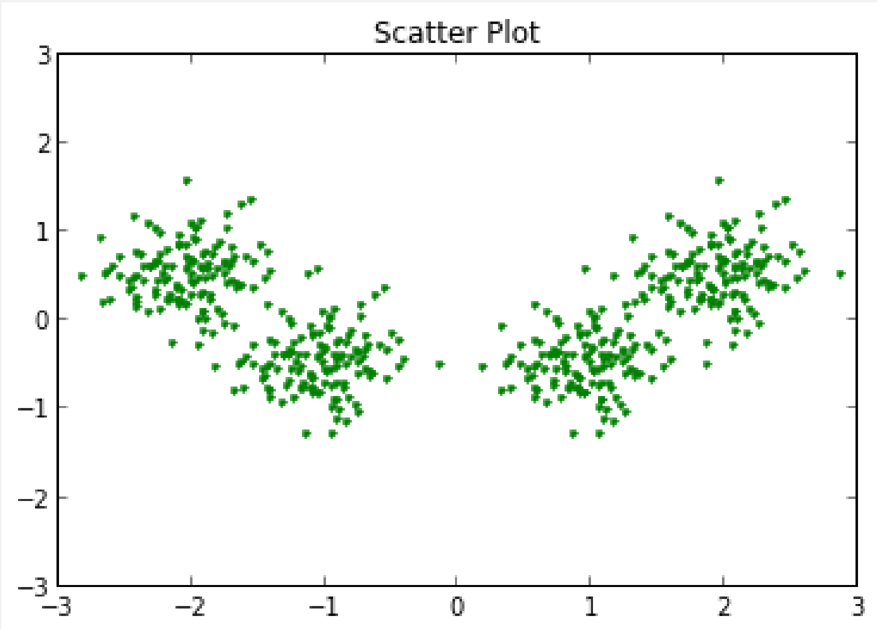
```
def plotCluster(X,Y,title,colors,ran,m, W):
   fig = plt.figure()
   ax = fig.add_subplot(111)
   ax.axis([-ran,ran,-ran,ran])
   for i in range (len(X)):
      #find the max probability
      for q in range (k):
         if(q == 0):
            m_max = m[i][q]
            p = q
         else:
            if(m_max < m[i][q]):
               m_max = m[i][q]
               p = q
      ax.plot(X[i],Y[i],colors[p]+'.')
   for i in range (len(W)):
      ax.plot(W[i][0],W[i][1],colors[i]+'D')
      ax.plot(W[i][0],W[i][1],'y'+'H')
   ax.set_title(title)
   plt.show()
```

```
def assignPoint(W,x,y):
    k = len(W)
    for i in range(k):
        if(i==0):
            min_distance = distance(W[i][0],W[i][1],x,y)
            min_p = i
        else:
            d = distance(W[i][0],W[i][1],x,y)
            if(d < min_distance):
                min_distance = d
                min_p = i
    return min_p

def drawBoundary(X,Y,title,ran, W_init, W, fine):
    fig = plt.figure()
    ax = fig.add_subplot(111)
    ax.axis([-ran,ran,-ran,ran])

    ax.plot(X,Y,'g'+'.')

    for i in range (len(W_init)):
        ax.plot(W_init[i][0],W_init[i][1],'r'+'H')

    for i in range (len(W)):
        ax.plot(W[i][0],W[i][1],'k'+'H')

    ax.set_title(title)

    ran = float(ran)
    unit = 2*ran/fine
    print 'unit',unit
    for i in range(fine):
        x = -ran + i*unit
        for j in range(fine):
            y = -ran + j*unit
            #print x,y
            p0 = assignPoint(W,x,y)
            p1 = assignPoint(W,x+unit,y)
            p2 = assignPoint(W,x-unit,y)
            p3 = assignPoint(W,x,y+unit)
            p4 = assignPoint(W,x,y-unit)
            if(p0==p1 and p1==p2 and p2==p3 and p3==p4):
                continue
            else:
                ax.plot(x,y,'y.')
    plt.show()
```

```
#read data
data = loadtxt("cluster.dat")
print data.shape
```

```
X = data[0,:]
Y = data[1,:]

plotScatter(X,Y,"Scatter Plot", 'g', 3)
```

```
(2, 500)
```

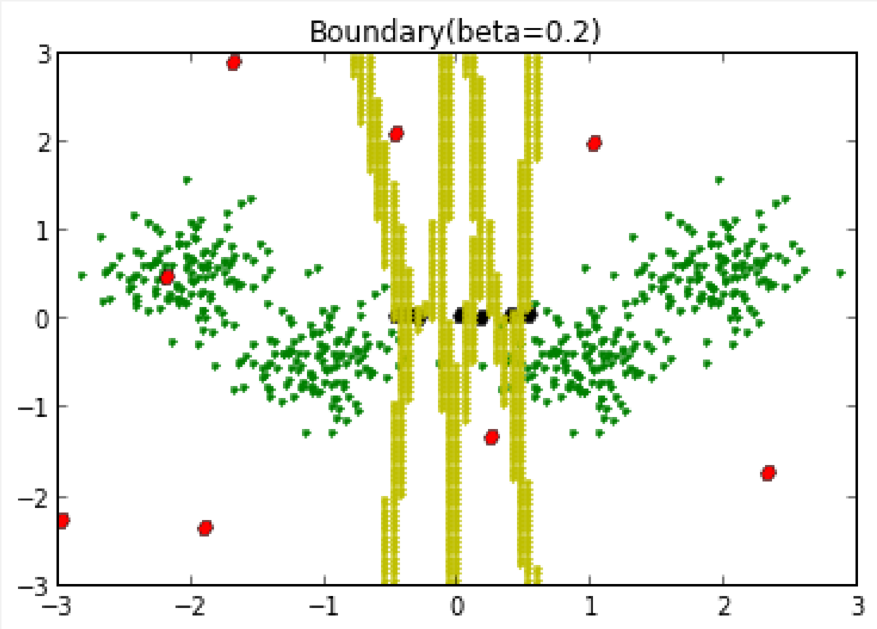


2.1 Non-Annealing

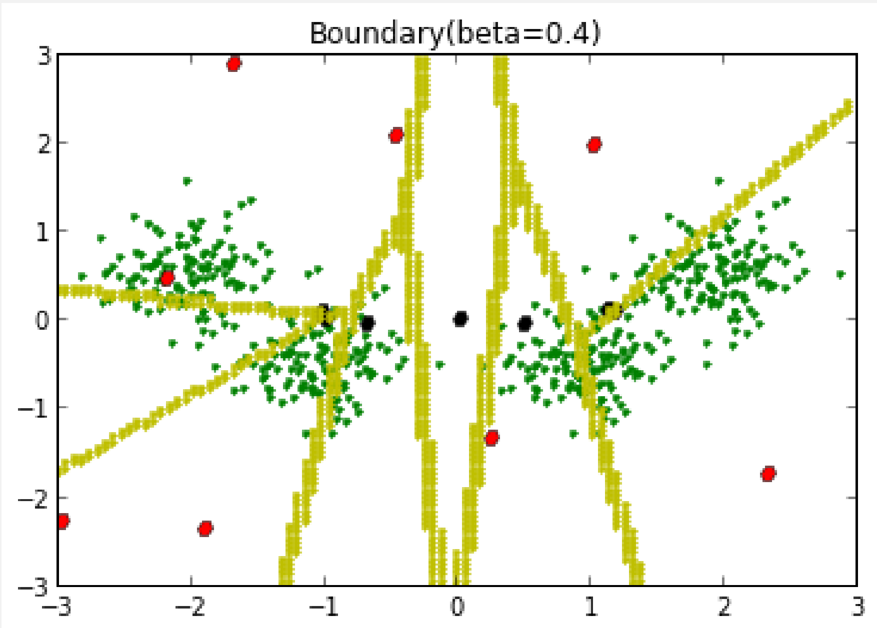
```
k = 8
rSeed = 100
W_init = init_w(k,rSeed)
print "W_init"
print matrix(W_init)
gamma = 0.01
ita = 1.1
W_result = [ W_init[:][:] for i in range (100)]
m_result = [ m[:][:] for i in range (100)]
for t in range(100):
    beta0 = 0.2 * (t+1)
    betaf = beta0
    W_return , m_return = kmeans_soft(X,Y,k,gamma,W_init,beta0,ita,betaf)
    W_result[t] = W_return[:][:]
    m_result[t] = m_return[:][:]
    if(t<10 or t%10==0):
        W_plot = W_result[t][:][:]
        drawBoundary(X,Y,"Boundary(beta="+str(beta0)+")",3, W_init, W_plot, 100)
```

```
W_init
[[ 0.26042965 -1.32978369]
```

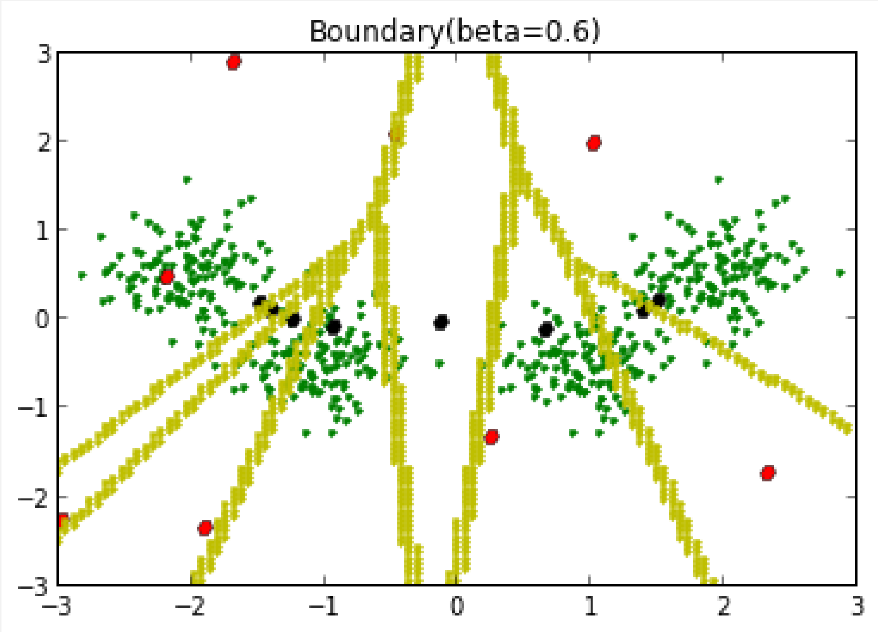
```
 [-0.45289446  2.06865679]
 [-2.97168686 -2.27058528]
 [ 1.02449451  1.95511653]
 [-2.17976046  0.45055998]
 [ 2.34793173 -1.74478727]
 [-1.88803068 -2.34973866]
 [-1.68181504  2.87174271]]
unit

0.06
```



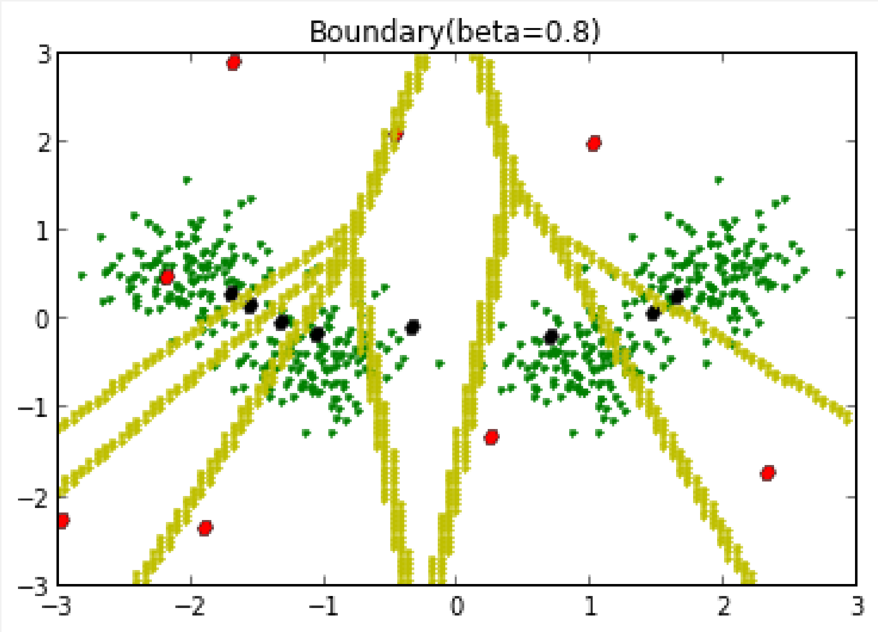

```
unit 0.06
```



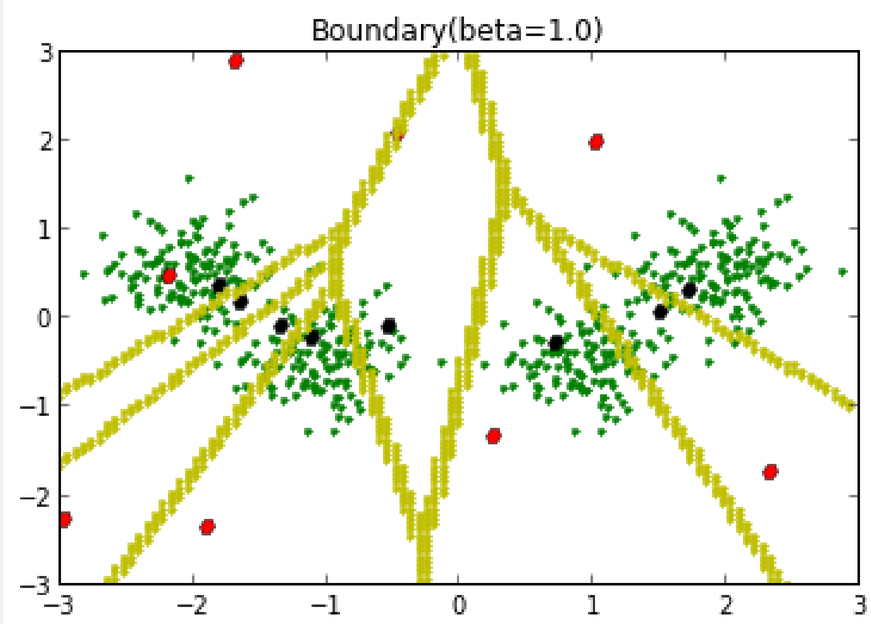
unit 0.06



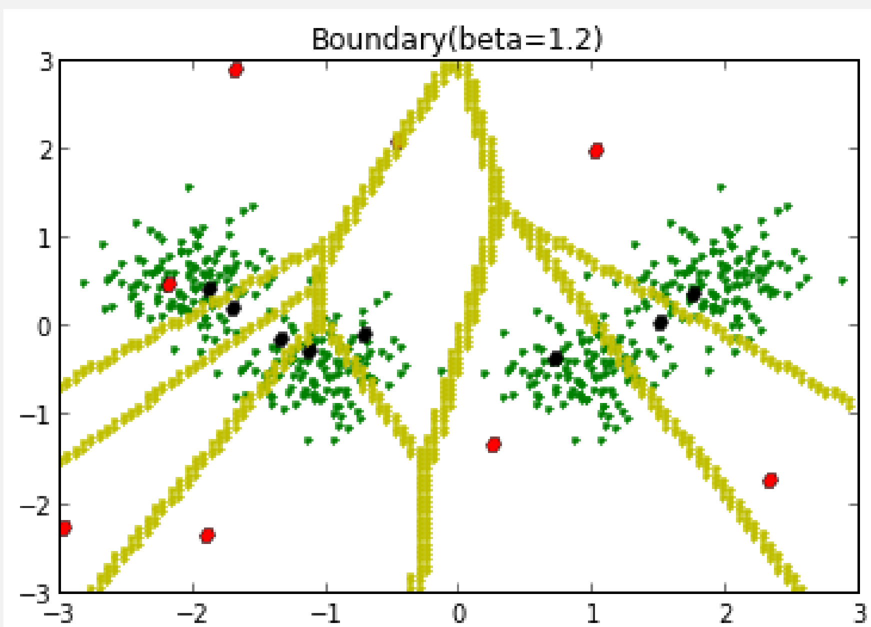
unit 0.06



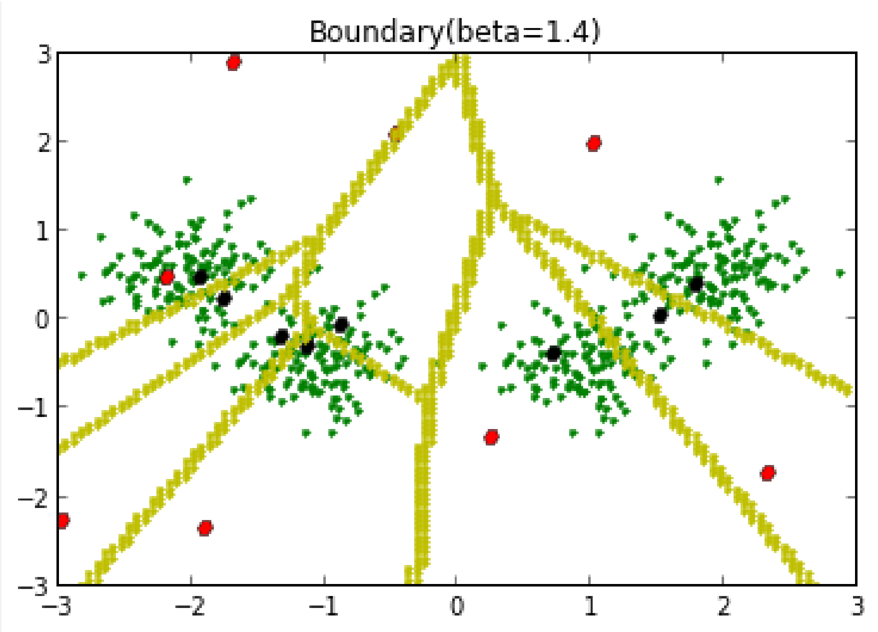
unit 0.06



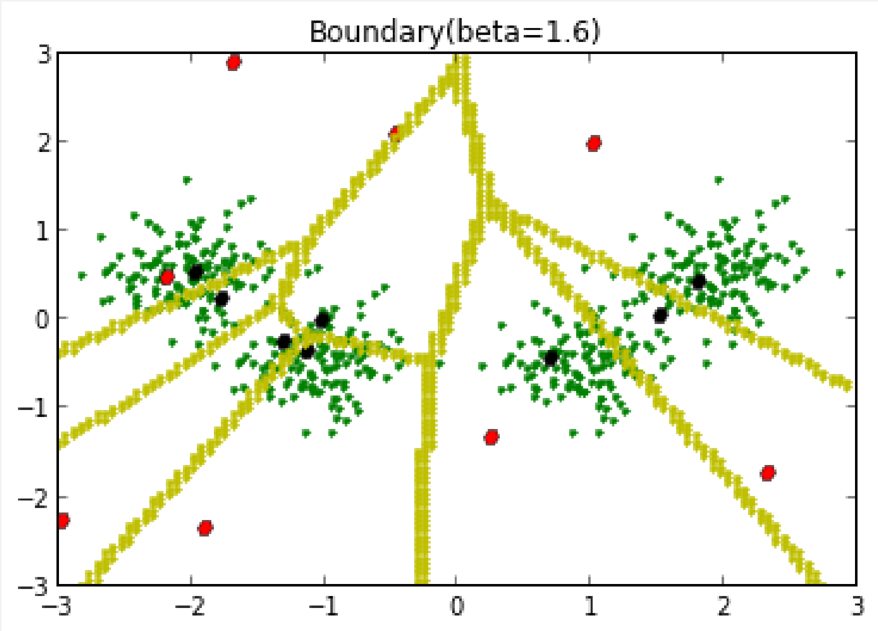
unit 0.06



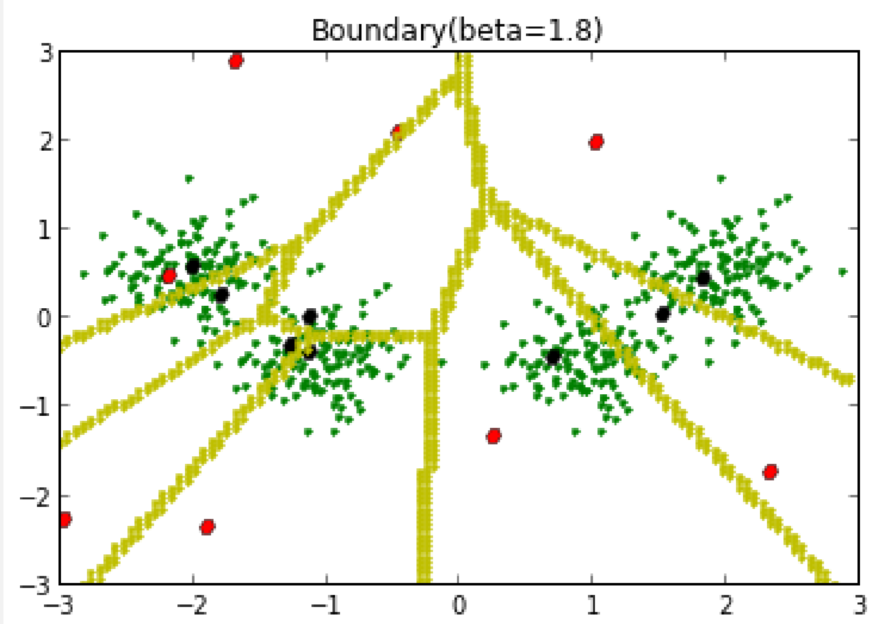
unit 0.06



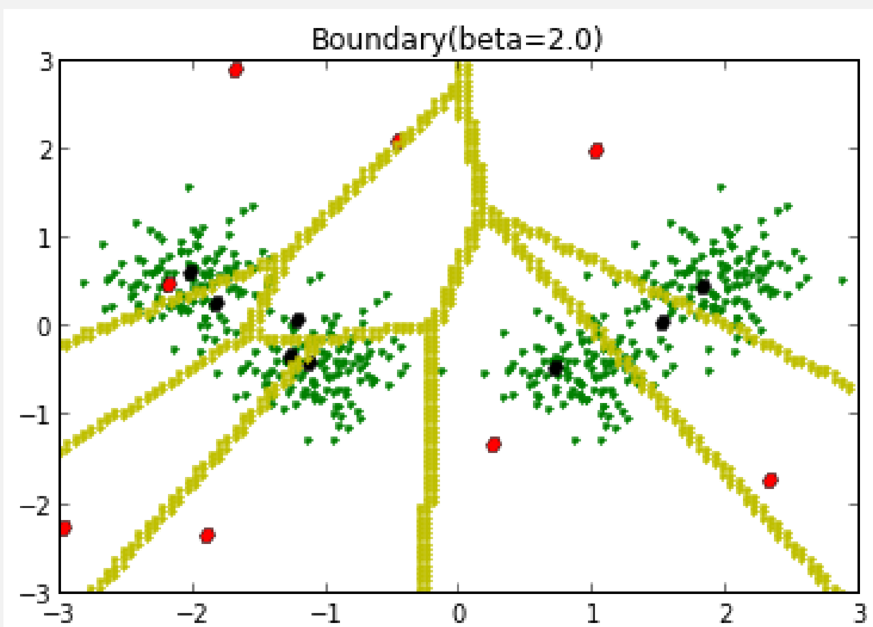
unit 0.06



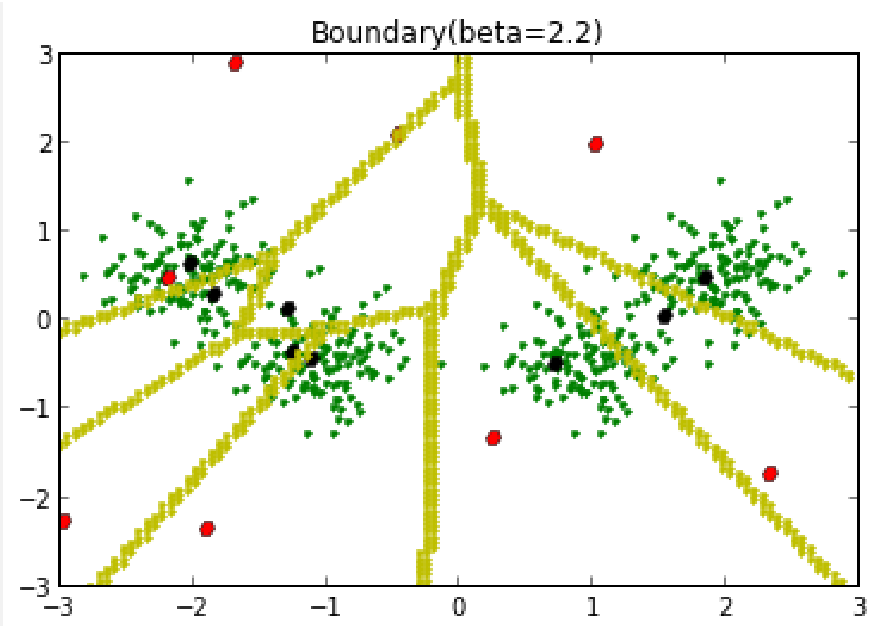
unit 0.06



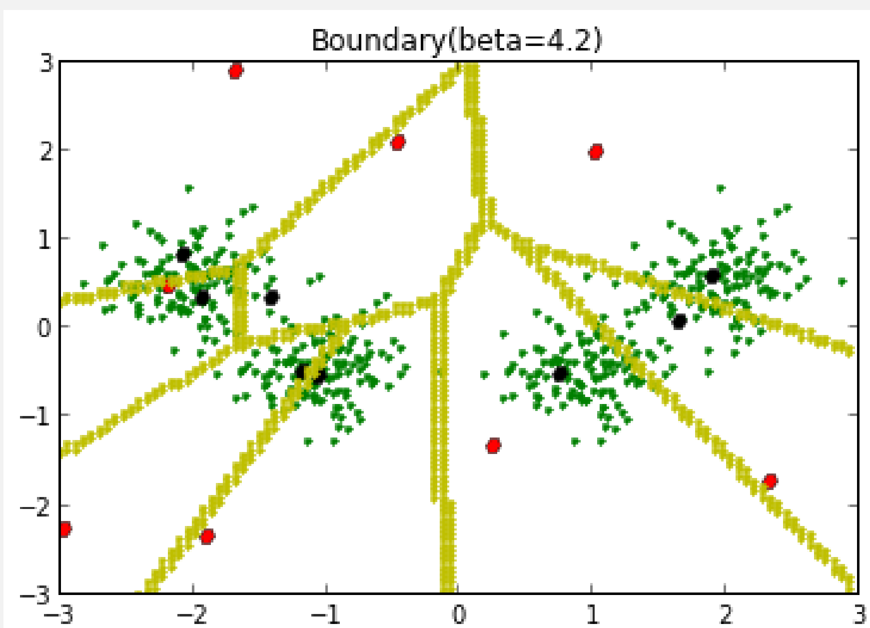
unit 0.06



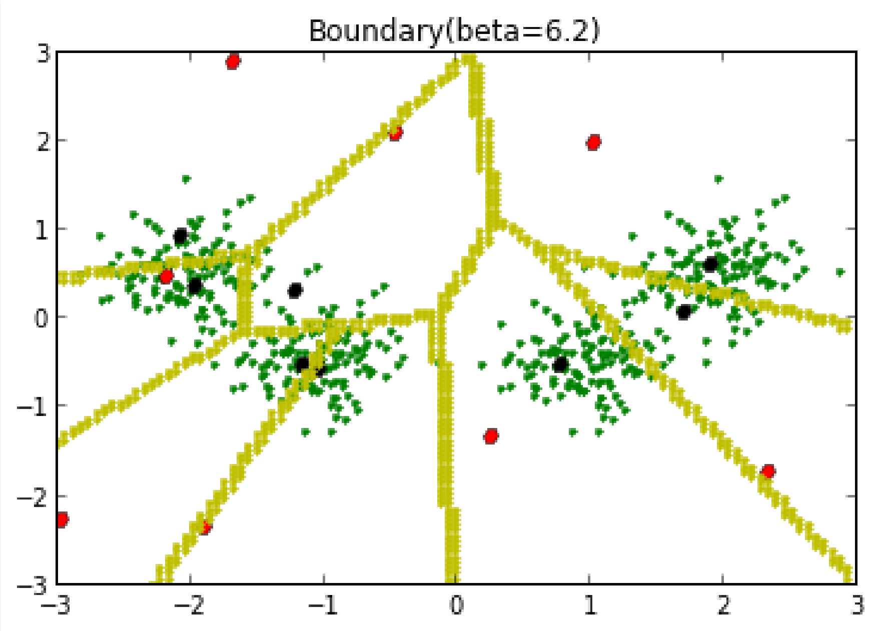
unit 0.06



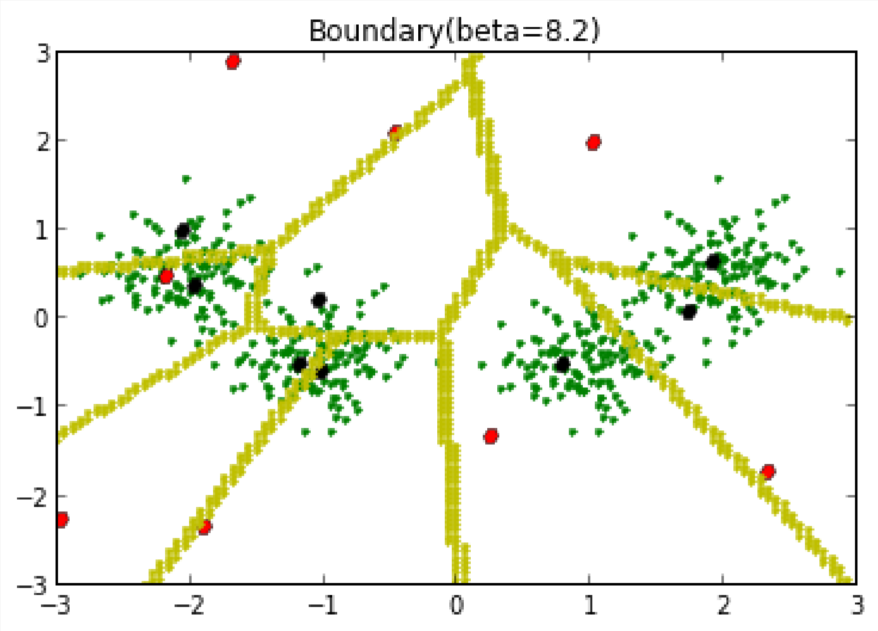

```
unit 0.06
```



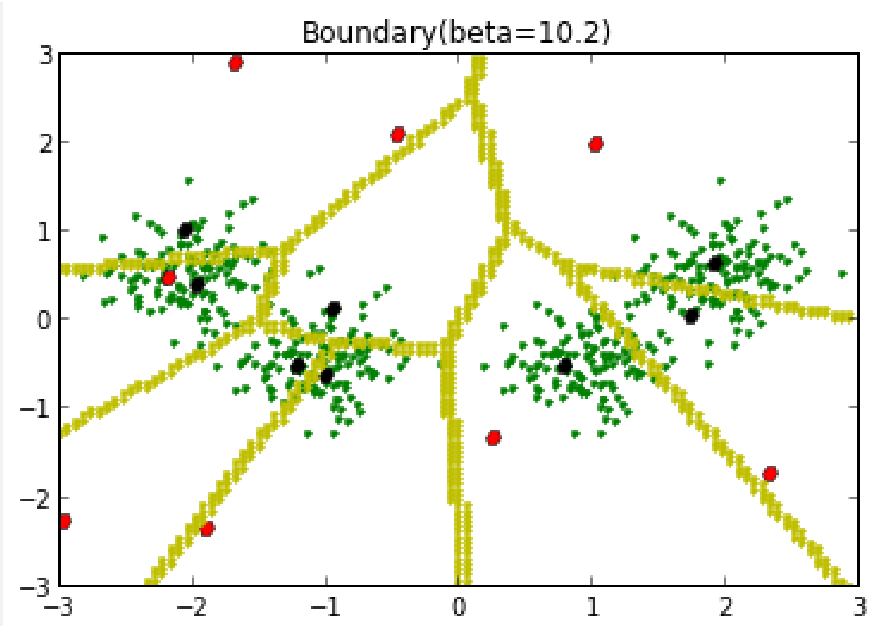

```
unit 0.06
```



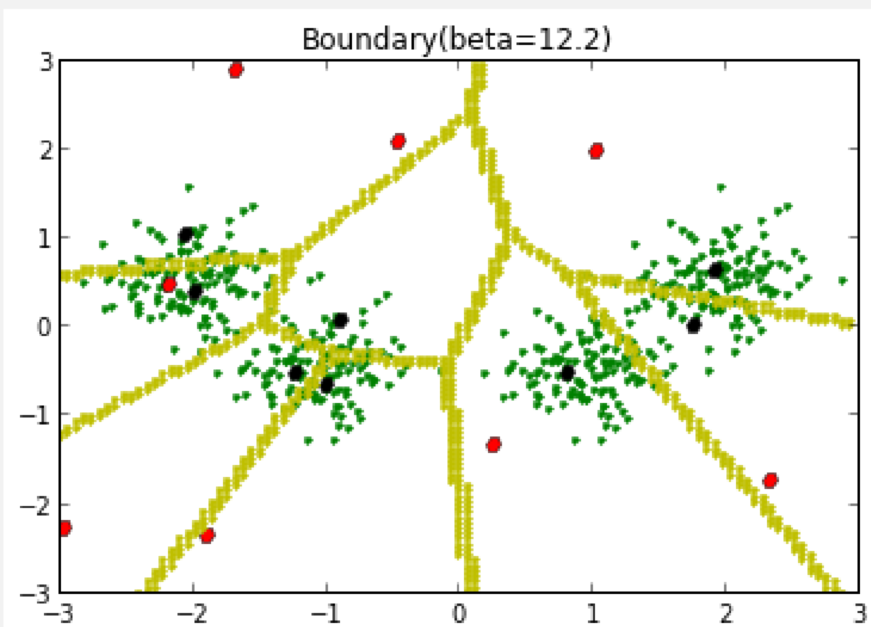

```
unit 0.06
```



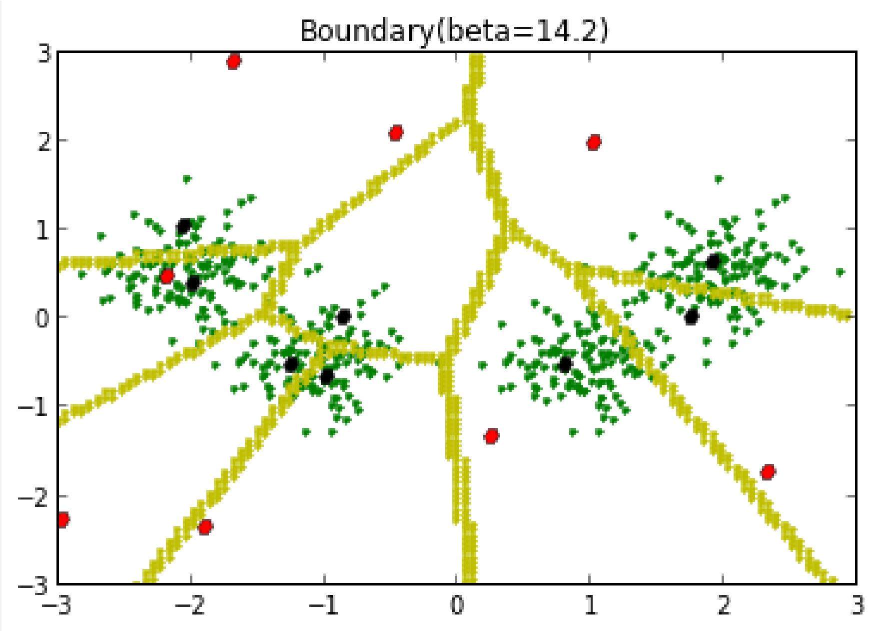

```
unit 0.06
```



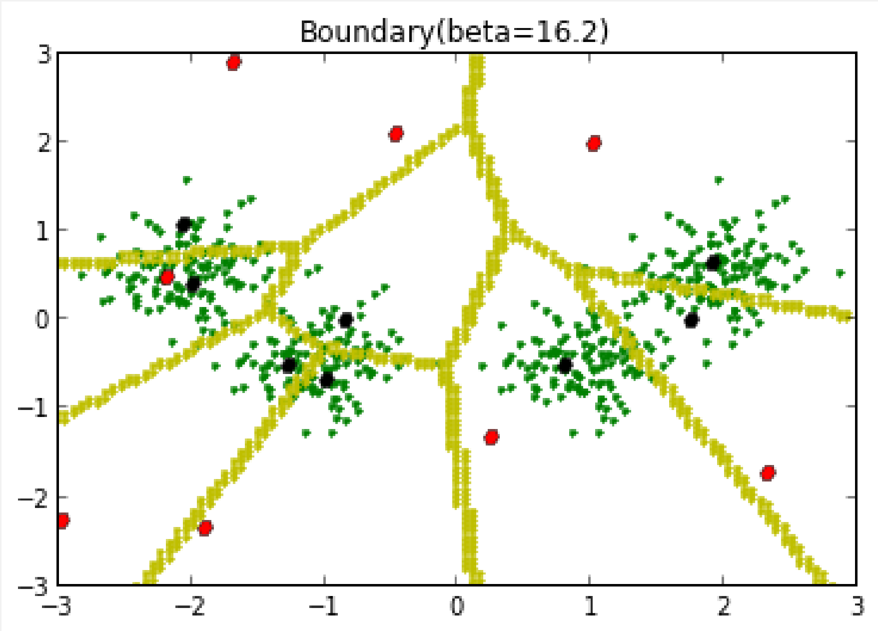

```
unit 0.06
```



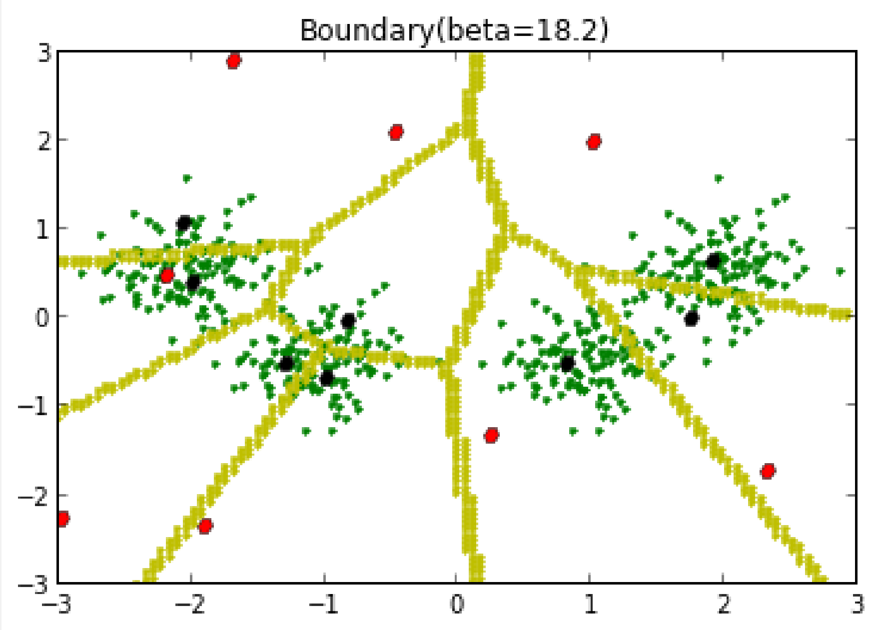

```
unit 0.06
```



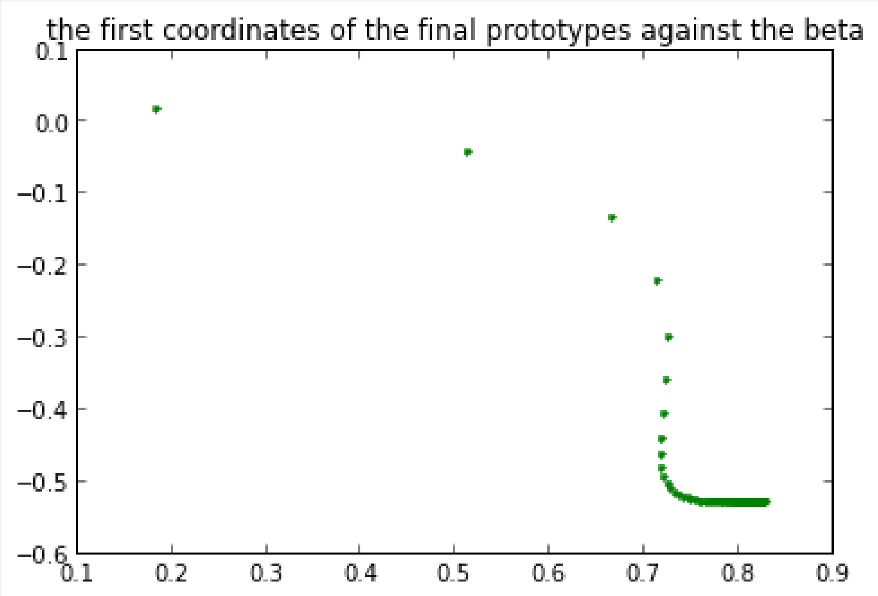

```
unit 0.06
```




```
unit 0.06
```



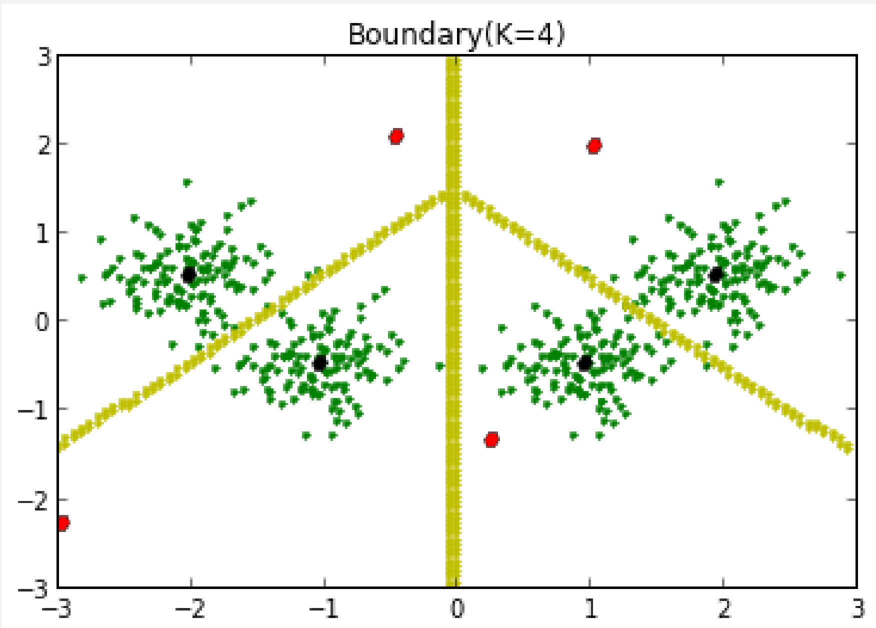

```
#Plot the first coordinates of the final prototypes against the beta
W_first_x = [0 for i in range (100)]
W_first_y = [0 for i in range (100)]
for t in range(100):
    beta0 = 0.2 * (t+1)
    W_first_x[t] = W_result[t][0][0]
    W_first_y[t] = W_result[t][0][1]
plotScatter2(W_first_x[:], W_first_y[:], "the first coordinates of the final prototypes
     against the beta")
```



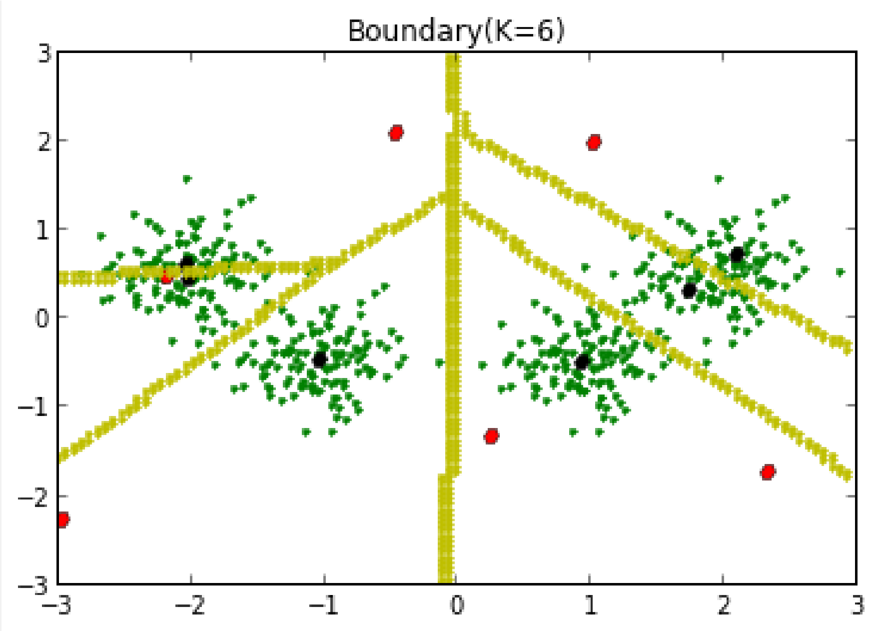
2.2 Annealing

```
k_array = [ 4, 6, 8 ]
rSeed = 100

gamma = 0.01
ita = 1.1
beta0 = 0.2
betaf = 20


W_result2 = [ W_init[:][:] for i in range (len(k_array))]
m_result2 = [ m[:][:] for i in range (len(k_array))]

for t in range(len(k_array)):
    W_init = init_w(k_array[t],rSeed)
    W_return , m_return = kmeans_soft(X,Y,k_array[t],gamma,W_init,beta0,ita,betaf)
    W_result[t] = W_return[:][:]
    m_result[t] = m_return[:][:]
    W_plot = W_result[t][:][:]
    drawBoundary(X,Y,"Boundary(K="+str(k_array[t])+")",3, W_init, W_plot, 100)
```

```
unit 0.06
```




```
unit 0.06
```




```
unit 0.06
```