Fengnan Wang (fwang40)

My code

./hw8.py

```
#!/usr/local/bin/python
import numpy as np
import matplotlib.pyplot as plt
import random
import cvxopt
import cvxopt.solvers
import pylab as pl
x=[]
y=[]
C=[]
for i in range(0,100):
    x.append(random.uniform(0,1))
    y.append(random.uniform(0,1))
    C.append([x[i],y[i]])
C=np.array(C)
#print 'C',C
"""
plt.plot(x,y,'ko')
plt.xlabel('x')
plt.ylabel('y')
plt.title('input patterns')
plt.show()
x_origin = np.linspace(0, 1, 100)
y_origin = np.linspace(0, 1, 100)
x_origin, y_origin = np.meshgrid(x_origin,y_origin)
line = plt.plot(x_origin, np.sin(10*x_origin)/5.0 +0.3, 'k',
linewidth=2)
```

```
F = (x_origin - 0.5)**2 + (y_origin - 0.8)**2-0.15**2
plt.contour(x_origin,y_origin,F,[0])
plt.show()
"""
C0=[]
C1=[]
d=[0]*100
def classifer(x,y):
    for i in range(100):
        if y[i] < np.sin(10*x[i])/5.0 +0.3 or  (x[i] - 0.5)**2 +
(y[i] - 0.8)**2 < 0.15**2:
            d[i]=1.0
            C1.append([x[i],y[i]])
            X1=np.array(C1)
        else:
            d[i]=-1.0
            C0.append([x[i],y[i]])
            X0=np.array(C0)
    return d,C0,C1,X1,X0
d,C0,C1,X1,X0=classifer(x,y)
d1=np.ones(len(C1))
d0=np.ones(len(C0))*-1
d=np.array(d)
print 'C0',C0
print 'C1',C1
print 'd',d,type(d)
"""
plt.plot(*zip(*C0), marker='o', color='r', ls='')
plt.plot(*zip(*C1), marker='*', color='k', ls='')
x_origin = np.linspace(0, 1, 100)
```

```
y_origin = np.linspace(0, 1, 100)
x_origin, y_origin = np.meshgrid(x_origin,y_origin)
line = plt.plot(x_origin, np.sin(10*x_origin)/5.0 +0.3, 'k',
linewidth=2)
F = (x_origin - 0.5)**2 + (y_origin - 0.8)**2-0.15**2
plt.contour(x_origin,y_origin,F,[0])
plt.show()
"""
#linear_kernel
def k1(x1,x2):
    return np.dot(x1,x2)
#polynomial_kernel
def k2(x1,x2,d=3):
    return (1+np.dot(x1,x2))**d
#gaussian_kernel
def k3(x1,x2,sigma=0.17):
    x1=np.array(x1)
    x2=np.array(x2)
    return np.exp(-np.linalg.norm(x1-x2)**2/(2*(sigma**2)))
# k matrix
k=np.zeros((100,100))
#print 'C[2]',C[2],'C[4]',C[4]
#print np.dot(C[2],C[4])
for i in range(100):
    for j in range(100):
        k[i,j]=k3(C[i],C[j])
print 'k',k
print 'x',C
print 'd',d
m,n=C.shape
```

```
P=cvxopt.matrix(np.outer(d,d)*k)
q=cvxopt.matrix(np.ones(m)*-1)
A=cvxopt.matrix(d,(1,m))
print A,len(A)
b=cvxopt.matrix(0.0)
G=cvxopt.matrix(np.diag(np.ones(m)*-1))
h=cvxopt.matrix(np.zeros(m))
solution=cvxopt.solvers.qp(P,q,G,h,A,b)
a=np.ravel(solution['x'])
print 'a',a,len(a)
def weight(a,K):
    sv=a>1e-4
    ind=np.arange(len(a))[sv]
    a1=a[sv]
    X_sv=C[sv]
    sv_d=d[sv]
    print "%d support vectors out of %d points" % (len(a1), m)
    b=0
    for i in range(len(a1)):
        b += sv_d[i]
        b -= np.sum(a1*sv_d*K[ind[i],sv])
    b /= len(a1)
    return a1,sv_d,X_sv,b
def project(x,a1,sv_d,X_sv,b):
    # x equals to X_train
    y_p =np.zeros(len(x))
    for i in range(len(x)):
        s=0
        for a,sv_d,sv in zip(a1,sv_d,X_sv):
            s+=a*sv_d*k3(x[i],sv)
```

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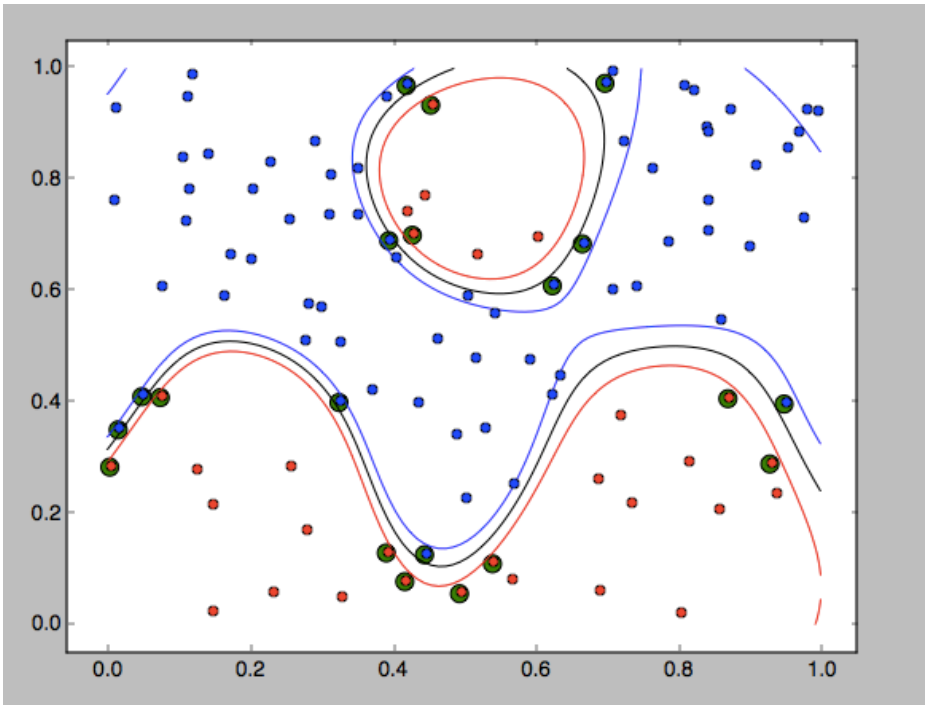
        y_p[i] = s

        return y_p+b
a1,sv_d,X_sv,b = weight(a,k)
y_p = project(C,a1,sv_d,X_sv,b)
pl.plot(X0[:,0],X0[:,1],'ro')
pl.plot(X1[:,0],X1[:,1],'b*')
pl.scatter(X_sv[:,0], X_sv[:,1], s=100, c='k')
X1, X2 = np.meshgrid(np.linspace(0,1,100), np.linspace(0,1,100))
X = np.array([[x1, x2] for x1, x2 in zip(np.ravel(X1),
np.ravel(X2))])
Z = project(X,a1,sv_d,X_sv,b).reshape(X1.shape)
pl.contour(-X1, -X2, -Z, [0.0], colors='k', linewidths=0.1)
pl.contour(-X1, -X2, -(Z + 1), [0.0], colors='b', linewidths=0.1)
pl.contour(-X1, -X2, -(Z - 1), [0.0], colors='r', linewidths=0.1)
pl.axis("tight")
pl.show()
pcost      dcost      gap    pres   dres
 0: -2.6120e+01 -7.6343e+01  3e+02  1e+01  2e+00
 1: -6.2178e+01 -1.1771e+02  1e+02  5e+00  1e+00
 2: -1.5538e+02 -2.2250e+02  1e+02  4e+00  9e-01
 3: -2.7706e+02 -3.7119e+02  1e+02  3e+00  6e-01
 4: -3.4311e+02 -4.2798e+02  1e+02  2e+00  4e-01
 5: -3.7154e+02 -3.9033e+02  2e+01  3e-01  5e-02
 6: -3.7319e+02 -3.7728e+02  5e+00  5e-02  1e-02
 7: -3.7374e+02 -3.7395e+02  2e-01  6e-04  1e-04
 8: -3.7387e+02 -3.7388e+02  4e-03  6e-06  1e-06
 9: -3.7387e+02 -3.7387e+02  7e-05  6e-08  1e-08
Optimal solution found.
a
```

```
[1.90571623e-08  5.10348355e-07  7.94454008e-08  1.88649778e-08
2.48678583e-08  1.97631827e+00  7.96577710e+01  2.61665669e-07
7.35168407e-08  2.89610175e-08  3.64258727e-08  1.15228464e+01
8.32252105e+01  1.28518723e+01  2.65503858e-08  4.78784872e+01
2.79736956e-07  1.24826341e+02  1.26264164e-07  6.12308695e+00
1.52021783e-08  1.49643021e-07  2.20483156e-08  4.83943949e-08
3.62109162e-05  2.06763404e-08  3.47317645e-08  4.78140445e-08
4.65738001e-08  5.81275312e+00  1.23520605e+00  6.06106852e-08
1.20543393e-07  1.87821778e-06  4.95689540e-07  5.80456713e-07
4.48604708e-08  2.76765093e-07  1.73990441e-07  4.73966905e-08
2.23623512e-07  4.66996029e-08  2.87915011e-08  7.67236519e-07
8.96076553e-08  3.11936595e-07  7.99819465e-08  1.47875885e-07
4.87263948e-08  2.34717811e-07  7.36014554e-08  1.32591788e+01
2.23946923e-07  2.64483578e-08  3.27471460e-08  9.77673883e-08
3.65658355e-08  1.51478918e-07  1.26066776e+02  2.02385066e-07
8.49500550e-08  1.19702890e-07  3.49067334e+00  6.60607520e-07
7.39532554e-07  3.03122750e-08  1.38972453e-07  3.04191338e-08
8.01985536e-08  1.37524767e+01  2.60847532e-07  2.10173467e-06
8.04138371e+00  3.22960906e-08  4.93885221e-08  1.25931693e+02
1.41029945e-06  4.55259653e-03  3.60929536e-08  1.15605194e-07
2.66674506e-08  2.97681614e-08  7.48939025e+01  1.38976581e-07
4.12622793e-08  2.10513683e-07  4.09852317e-08  6.18608479e-08
6.34572390e-08  5.39232987e-08  3.55573889e-08  3.56276143e-07
7.19886828e+00  3.21595261e-07  9.17235985e-08  4.23871852e-08
6.22311503e-08  7.04120167e-08  3.67091105e-08  4.81546313e-08]
20 support vectors out of 100 points
clf
[ 3.16096863  3.42877158  3.70695122 ..., -0.58140702 -0.53579287
 -0.49217292] (10000,) x1shape (100, 100)
I used contour function to implement my graph
```

And I tired different sigma to present my result.

Sigma=0.17



Sigma=0.175