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% ECE 559 Neural Network - Fall 2018
% Montagna Marco
% Homework 1

clear all
close all
clc

% input patterns
x=rand(2,100);
d=zeros(100,1);

% plot boundaries
angle=0:0.01:2*pi;
r=0.15;
x1=0.5;
x2=0.8;
xp=r*cos(angle);
yp=r*sin(angle);

figure(1);
plot(x1+xp,x2+yp,'b');
hold on
x1=linspace(0,1);
x2=(1/5)*sin(10*x1)+0.3;
plot(x1,x2,'b')
hold on

axis([0 1 0 1]);
hold on
grid on
xlabel('x1');
ylabel('x2');

% plot inputs
flag=false;
for i=1:100
    if x(2,i)<(1/5)*sin(10*x(1,i))+0.3 ||
 (x(2,i)-0.8)^2+(x(1,i)-0.5)^2<0.15^2
        d(i)=1;
        plot(x(1,i),x(2,i),'xr');
        if (x(2,i)-0.8)^2+(x(1,i)-0.5)^2<0.15^2
            flag=true;
        end
    else
        d(i)=-1;
        plot(x(1,i),x(2,i),'ok');
    end
end
if(flag==false)
    x(1,100)=0.5;
    x(2,100)=0.8;
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end

% solve quadratic minimization problem
% NOTE: I want to MAXIMIZE the minimum distance
A=[];
b=[];
H=zeros(100,100);
f=-1*ones(100,1);
Aeq=d';
beq=0;

% Gaussian Kernel
K=@(x,y)exp((-(norm(x-y)).^2)/0.5);

% Polynomial Kernel
% K=@(x,y)(1+x'*y).^5;

for i=1:100
    for j=1:100
        H(i,j)=d(i)*d(j)*K(x(:,j),x(:,i));
    end
end
[al,fval,exitflag,output,lambda]=quadprog(H,f,A,b,Aeq,beq,zeros(100,1),
[],[]);
if exitflag==1
    disp('Function converged to the solution.');
    flag=0;
elseif exitflag==0
    disp('Number of iterations exceeded options.MaxIterations.');
    flag=1;
else
    disp('Problem unsolved.')
    flag=1;
end

% if the optimization function converged
if flag==0
    k=find(al>=0.1,1);
    w=0;
    theta=0;
    for i=1:100
        w=w+al(i)*d(i)*K(x(:,i),x(:,k));
        theta=theta+al(i)*d(i)*K(x(:,i),x(:,k));
    end
    theta=d(k)-theta;
    g=w+theta;
    norm=abs(g);

    figure(2)
    % Support vectors
    k=find(al>=0.1);
    for i=1:length(k)
        if x(2,k(i))<(1/5)*sin(10*x(1,k(i)))+0.3 ||
 (x(2,k(i))-0.8)^2+(x(1,k(i))-0.5)^2<0.15^2
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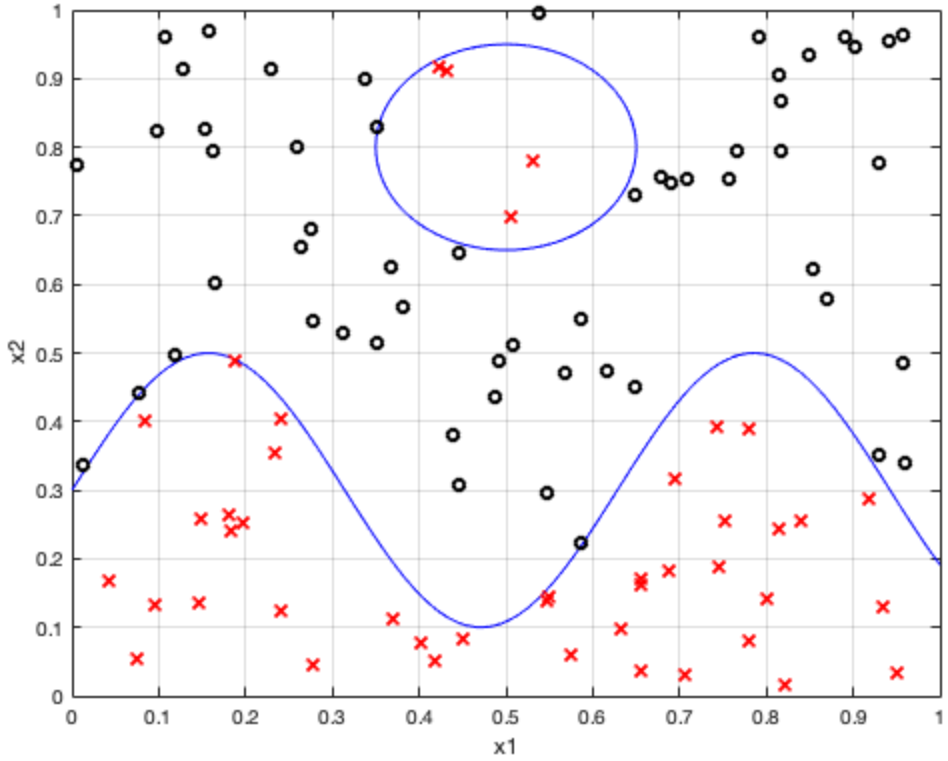
            plot(x(1,k(i)),x(2,k(i)),'rO','Markersize',10);
            hold on
        else
            plot(x(1,k(i)),x(2,k(i)),'kO','Markersize',10);
            hold on
        end
    end
    for i=1:100
        if x(2,i)<(1/5)*sin(10*x(1,i))+0.3 ||
 (x(2,i)-0.8)^2+(x(1,i)-0.5)^2<0.15^2
            d(i)=1;
            plot(x(1,i),x(2,i),'rx');
            hold on
        else
            d(i)=-1;
            plot(x(1,i),x(2,i),'ko');
            hold on
        end
    end
    %plot of the decision boundaries
    x1=linspace(0,1,1000);
    x2=linspace(0,1,1000);
    for i=1:1000
        for j=1:1000
            w=0;
            for k=1:100
                w=w+al(k)*d(k)*K(x(:,k),[x1(i);x2(j)]);
            end
            g=(w+theta)/norm;
            if abs(g)<0.1
                plot(x1(i),x2(j),'bl.','Markersize',0.5);
                hold on
            elseif abs(g-1)<0.1
                plot(x1(i),x2(j),'r.','Markersize',0.5);
                hold on
            elseif abs(g+1)<0.1
                plot(x1(i),x2(j),'k.','Markersize',0.5);
                hold on
            end
        end
    end
end
xlabel('x1');
ylabel('x2');
title('SVM')
```

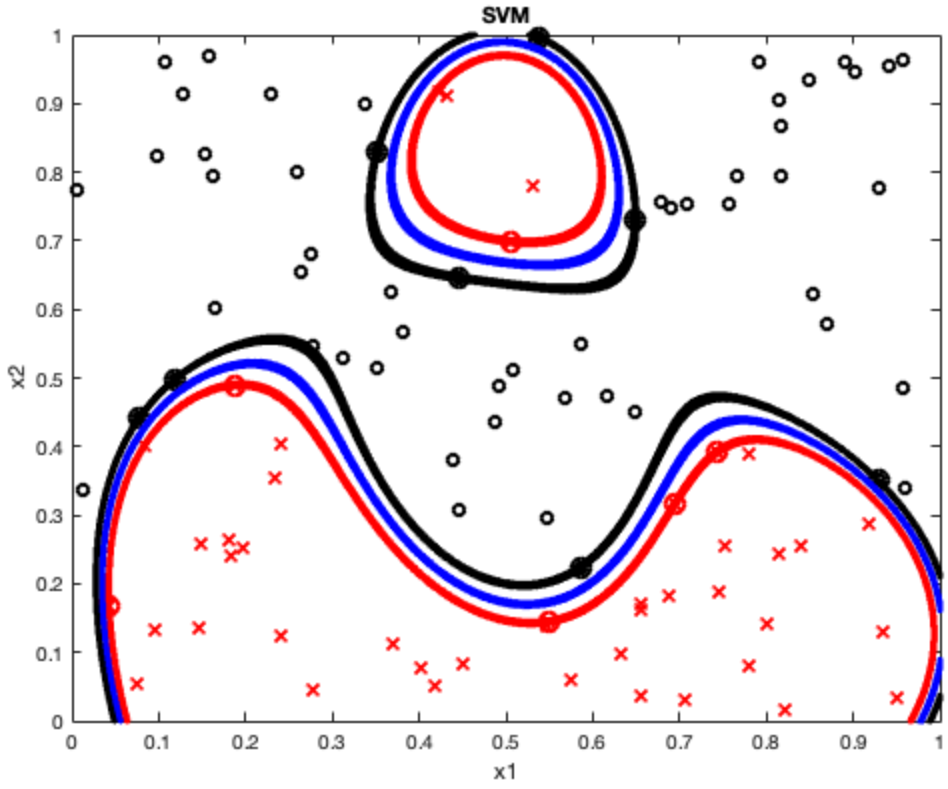
Minimum found that satisfies the constraints.

Optimization completed because the objective function is non-decreasing in
feasible directions, to within the default value of the optimality tolerance,

and constraints are satisfied to within the default value of the constraint tolerance.

Function converged to the solution.





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