EE 5322

INTELLIGENT CONTROL SYSTEMS

EXAM ONE

PREPARED BY:

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EE 5322 Intelligent Control
Spring 2019
Homework Pledge of Honor

On all homeworks in this class - YOU MUST WORK ALONE.

Any cheating or collusion will be severely punished.

It is very easy to compare your software code and determine if you worked together
Or if you found code online written by someone else.
It does not matter if you change the variable names.

Please sign this form and include it as the first page of all of your submitted homeworks.

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Typed Name: ADIL KHAN MOHAMMED

Pledge of honor:

"On my honor I have neither given nor received aid on this homework."

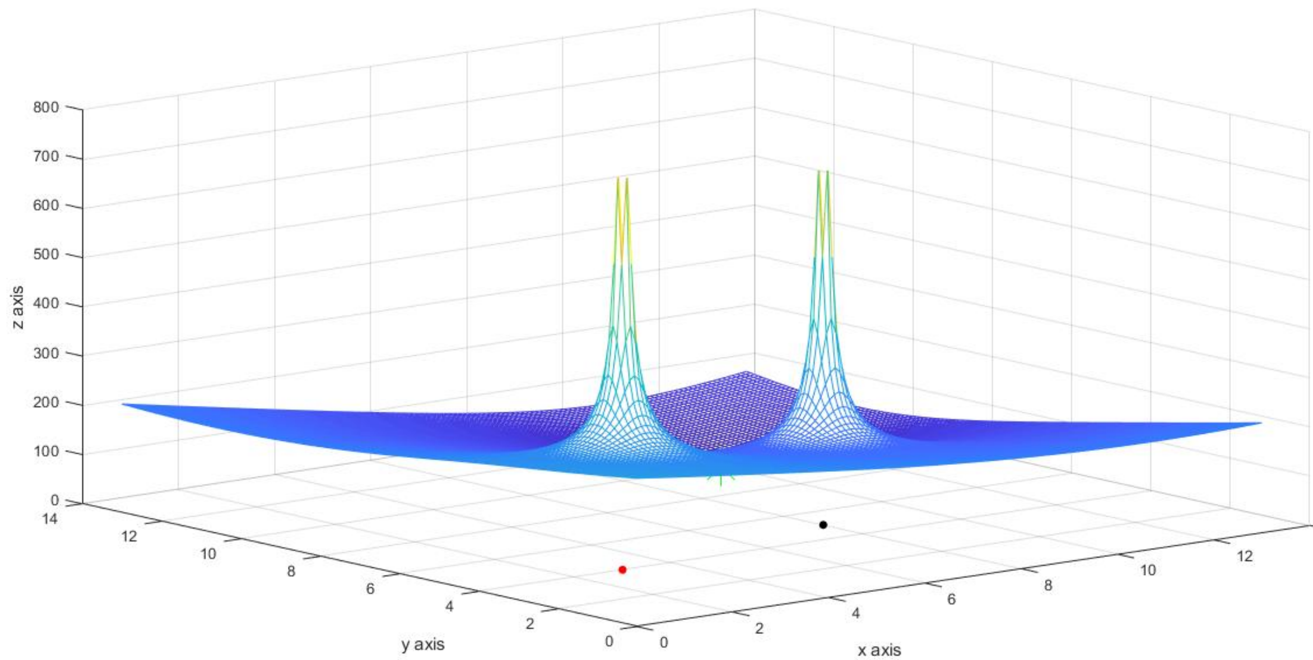
e-Signature: ADIL KHAN MOHAMMED

1) We have the following points set as goal and obstacles and need to plot the sum of the three fields.

We use the following code to obtain the plot.

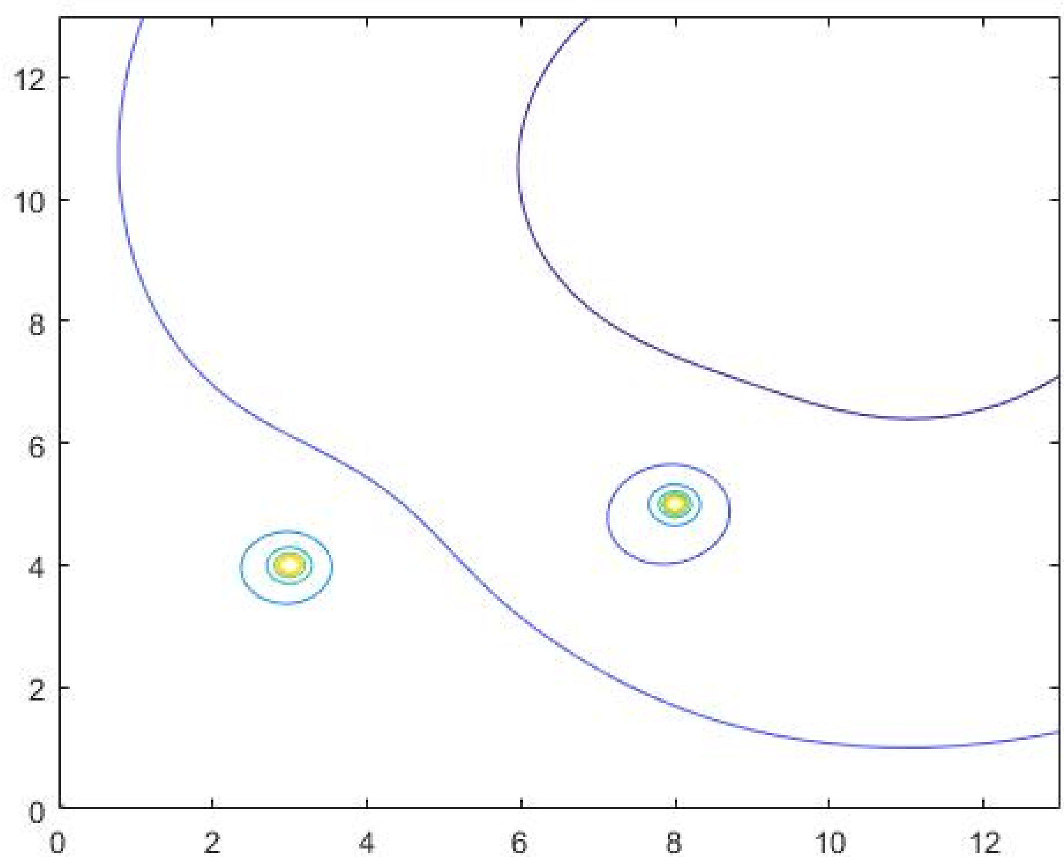
```
% defining the size of the plane and converting it into
mesh
a= 0:0.1:13;
b= 0:0.1:13;
[x,y]= meshgrid(a,b);
% defining the values of goals, obstacles, kt and ki
xG= [10;10];
x1= [3;4];
x2= [8;5];
kt= 20;
ki= 60;
% calculating the range and attractive potential
rt = sqrt((xG(1)-x).^2+(xG(2)-y).^2);
atrpot= kt*rt;
% calculating the range and repulsive potential for the
first obstacle
ri1 = sqrt((x1(1)-x).^2+(x1(2)-y).^2);
reppot1 = ki./ri1;
% calculating the range and repulsive potential for the
second obstacle
ri2 = sqrt((x2(1)-x).^2+(x2(2)-y).^2);
reppot2= ki./ri2;
% summing the attractive and repulsive potentials
sumofpot= (atrpot+reppot1+reppot2);
% plotting the 3D and contour plots
mesh(a,b,sumofpot);
xlabel('x axis')
ylabel('y axis')
zlabel('z axis')

% marking the points of goal and obstacles on the mesh
plot
hold on
plot(xG(1),xG(2),'*g','Markersize',25)
```

```
hold on
plot(x1(1),x1(2),'.r','markersize',18)
hold on
plot(x2(1),x2(2),'.k','Markersize',18)
figure
contour(x,y,sumofpot)
```



Here the goal xG(10,10) is shown by a green star.

Below is the contour plot.



2) a) We need to compute the forces acting on the vehicle.

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a) Compute the forces due to each obstacle & goal & compute total force.

We have the dynamics of the robot system

$$\dot{x} = v_T \cos\phi \cos\theta$$
$$\dot{y} = v_T \cos\phi \sin\theta$$
$$\dot{\theta} = \frac{v_T \sin\phi}{L}$$

where L = wheel base

We have $x_G = (10, 10)$ $K_G = 85$
$x_1 = (3, 4)$ $K_O = 50$
$x_2 = (8, 5)$

range $r_G = \sqrt{(x_G - x)^2 + (y_G - y)^2}$

The forces are obtained as

i) Attractive forces

$$F_{Gx}(x, y) = K_G \cdot \frac{x_G - x}{r_G} \Rightarrow 85 \cdot \frac{10 - x}{r_G}$$

$$F_{Gy}(x, y) = K_G \frac{y_G - y}{r_G} \Rightarrow 85 \cdot \frac{10 - y}{r_G}$$

(ii) Now we calculate the repulsive forces acting

$$F_{ix}(x,y) = -K_i \frac{x_i - x}{r_i^2} = -50 \cdot \frac{3-x}{r_i^2}$$

$$F_{iy}(x,y) = -50 \cdot \frac{4-y}{r_i^2}$$

For x(2) we have.

$$F_{ix}(x,y) = -50 \cdot \frac{8-x}{r_i^2}$$

$$F_{iy}(x,y) = -50 \cdot \frac{5-y}{r_i^2}$$

All the force components acting on the vehicle a

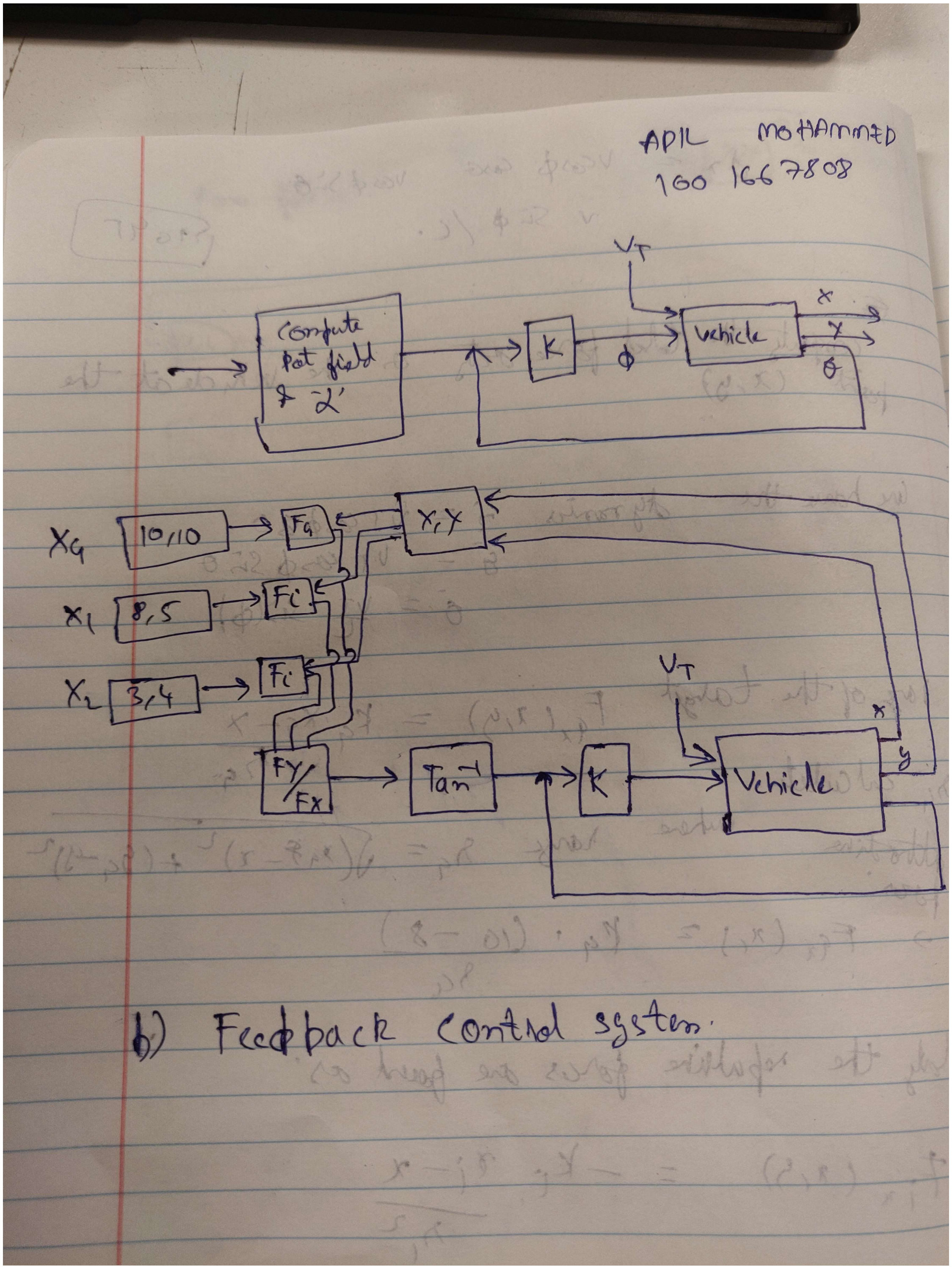
$$F_x = F_{gx} + F_{ix_1} + F_{ix_2}$$

$$F_y = F_{gy} + F_{iy_1} + F_{iy_2}$$

The angle of the force is obtained as :-

$$\alpha = \tan^{-1}\left(\frac{F_y}{F_x}\right)$$

b) The Feedback control system for the force field control system is obtained as



c) The following MATLAB code will help us in obtaining the trajectory of the robot from (0,0) to (13,13) with obstacles at (3,4) and (8,5).

```
function dx= Exam1_2(~,x)
% defining the values of goals, obstacles, kg and ko
xG= [10;10];
x1= [3;4];
x2= [8;5];
KG= 85;
Ko= 50;
%calculating the range and the attractive forces
rG= sqrt((xG(1)+x(1))^2+(xG(2)-x(2))^2);
FGx= KG*(xG(1)-x(1))/rG;
FGy= KG*(xG(2)-x(2))/rG;
%calculating the range and the repulsive forces wrt to
first obstacle
ri1= sqrt((x1(1)-x(1))^2+(x1(2)-x(2))^2);
Fi1x= -Ko*(x1(1)-x(1))/ri1^2;
Fi1y= -Ko*(x1(2)-x(2))/ri1^2;
%calculating the range and the repulsive forces wrt to
the 2nd obstacle
ri2= sqrt((x2(1)-x(1))^2+(x2(2)-x(2))^2);
Fi2x= -Ko*(x2(1)-x(1))/ri2^2;
Fi2y= -Ko*(x2(2)-x(2))/ri2^2;
%cummulating the forces
Fx= (FGx+Fi1x+Fi2x);
Fy= (FGy+Fi1y+Fi2y);
%angle of the force as seen from the robot
alpha= atan(Fy/Fx);
%defining the values of wheel speed 'v', wheel base
'L'& 'K'
v=1; L=2;
K=3;
%Taking the value of phi where theta is x(3)
ph= K*(alpha-x(3));
%defining the dynamics of xdot, ydot and theta dot
dx=[v*cos(ph)*cos(x(3));v*cos(ph)*sin(x(3));v*sin(ph)/L
];
end
```

In the script file ‘Exam1_22’ we have the following code stored.

```
 function[t,x] = Exam1_22()
%defining the values of goals, obstacles, kg and ko
time= [0 2045];
x0= [0;0;0];
xG= [10;10];
x1= [3;4];
x2= [8;5];
KG= 25;
Ko= 55;
% using the ode23 solver to call the function from
'Exam1_2'
[t,x]= ode23('Exam1_2',time,x0);
% plotting the resulting trajectory in (x,y) plane
plot(x(:,1),x(:,2),'k',xG(1),xG(2),'*g',x1(1),x1(2),'xb
',x2(1),x2(2),'xb')
axis([0 14 0 14])
xlabel('x axis')
ylabel('y axis')
legend('path of the robot')
end
```

The resulting figure is obtained as: