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%=======================================================
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%CS 455: Mobile Sensor Netorks
%Project 1: Flocking
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                    clc,clear
                    close all

%================ALGORITHM NUMBER=======================

                    ALG_NUM = 5;

%=============PARAMETER OF SIMULATION===================

d = 15;%Set desired distance among sensor nodes
k_scale = 1.2;%Set the scale of MSN
r = k_scale*d; %Set the active range
r_prime = .22*k_scale*r; %Set the active range of beta agent
epsilon = 0.1; %Set a constant for sigma norm
num_nodes = 10; %Set number of sensor nodes
n=2; %Set number of dimensions

F = 50; %actual value
Cv = .01;

    grid_size = 20; %20x20
    r = 17; %set communication range
    r_s = 17*ones(num_nodes,1); %measurement radius
    num_nodes = 10; %Randomly generate nodes
    grid_size = 4; %4x4
    r = 2; %set communication range
    r_s = 3*ones(num_nodes,1); %measurement radius

%Place F Value on Graph
subplot(1,3,1);
plot(.5*grid_size, .5*grid_size, 's', 'LineWidth' ,.1 , 'MarkerEdgeColor', 'r',
    'MarkerFaceColor', 'r', 'MarkerSize', 10)
hold on

nodes = grid_size.*rand(num_nodes, n) + grid_size.*repmat([0 1], num_nodes, 1);
    %Randomly generate initial positions of MSN
p_nodes = zeros(num_nodes,n); %Set initial velocties of MSN
delta_t_update = 0.08; %Set time step
t = 0:delta_t_update:7;% Set simulation time

if ALG_NUM == 5 %=================SET OBSTACLES==========================
    obstacles = [50, 100; 150 80; 200, 230; 280 150]; %set positions of
        obstacles
    Rk = [20; 10; 15; 8]; %Radii of obstacles
    num_obstacles = size(obstacles,1); %Find number of obstacles
end

if ALG_NUM ~= 1 %=========SET A STATIC TARGET================
    qt1 = [150 150]; %Set position of the static target (gamma agent)
    pt1= [0 0]; %Set initial velocity of the target
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end

nodes_old = nodes; %KEEP previous positions of MSN
q_mean = zeros(size(t,2), n); %Save positions of COM (Center of Mass)
p_mean = zeros(size(t,2), n); %Save velocities of COM (Center of Mass)
Connectivity = []; %save connectivity of MSN
q_nodes_all = cell(size(t,2), num_nodes); %creates cell array to store history
    of system pos
p_nodes_all = cell(size(t,2), num_nodes); % -   -   -   -   -   -   -   -   -
    -   -   -vel

%compute grid average
x_ave = 0;
y_ave = 0;
for i = 1:num_nodes
    x_ave = x_ave + nodes(i,1);
    y_ave = y_ave + nodes(i,2);
end
q_ave = (1/num_nodes)*[x_ave y_ave];

%Compute Variance Matrix (works for all cases in static system
Var = zeros(num_nodes,1);
for i = 1:num_nodes
    diff = norm(nodes(i,:) - q_ave);
    Var(i) = (diff^2 + Cv) / (r_s(i)^2);
end

%initial value
nodes_va = F.*ones(num_nodes,1) + normrnd(0,Var(:)); %Add measurement for each
    node: yi= theta + v_i
nodes_va0 = nodes_va; %save the initial measurement

%Define History
history = []; %add nodes_va_next after each iteration
history(1,:) = nodes_va0; %each column is a history vector

nFrames = 20; %set number of frames for the movie
mov(1:nFrames) = struct('cdata', [],'colormap', []); %Preallocate movie
    structure
iteration = 2;
nodes_ave = zeros(num_nodes,1);
nodes_wht = zeros(num_nodes,1);
nodes_avef = zeros(num_nodes,1);
nodes_whtf = zeros(num_nodes,1);
for iteration = 1:length(t)
            %Line Trajectory of a moving target
            qt_x1 = t(iteration);
            qt_y1 = t(iteration);

            %compute position of target
            qt1(iteration,:) = [qt_x1, qt_y1];

            %compute velocities of target
            pt1(iteration,:) = (qt1(iteration,:) - qt1(iteration-1,:)) /
                delta_t_update;
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        plot(qt1(:,1),qt1(:,2),'ro','LineWidth',2,'MarkerEdgeColor','r',
            'MarkerFaceColor','r', 'MarkerSize',4.2)
        hold on

    %=====================(LOOP) UPDATE PROCESS for MSN=====================

        [Nei_agent, A] = findneighbors1(nodes, r);
        [Ui] = inputcontrol_Algorithm2(ALG_NUM, num_nodes, nodes, Nei_agent, n,
            epsilon, r, d, qt1, pt1, p_nodes);

    p_nodes = (nodes - nodes_old)/delta_t_update; %COMPUTE velocities of sensor
        nodes
    p_nodes_all{iteration} = p_nodes; %SAVE VELOCITY OF ALL NODES
    nodes_old = nodes;
    nodes = nodes_old + p_nodes*delta_t_update + .5*Ui*delta_t_update*
        delta_t_update;
    q_mean(iteration,:) = mean(nodes); %Compute position of COM of MSN

    for l = 1:num_nodes %sum the neighbor weights
        %compute Wii
        Wii = weighted_design2(l ,l ,Var ,Nei_agent ,Cv ,r ,r_s);

        %compute sum of Wij*X_j
        sum1 = 0;
        sum2 = 0;
        for m = 1:size(Nei_agent{l},1) %iterates through neighbors
            sum1 = sum1 + (nodes_va(Nei_agent{l}(m)) * weighted_design2(i ,
                Nei_agent{l}(m) ,Var ,Nei_agent ,Cv ,r ,r_s));
            sum2 = sum2 + (nodes_va(Nei_agent{l}(m)) * weighted_metropolis(i,
                Nei_agent{l}(m), Nei_agent));
        end

        %get estimates X_i
        nodes_ave(l) = Wii*nodes_va(l) + sum1;
        nodes_wht(l) = Wii*nodes_va(l) + sum2;
    end

    if ALG_NUM ~= 1
        plot(q_mean(:,1),q_mean(:,2),'ro','LineWidth',2,'MarkerEdgeColor','k',
            'MarkerFaceColor','k','MarkerSize',4.2)
        hold on
    end

    p_mean(iteration,:) = mean(p_nodes); %Compute velocity of COM of MSN
    q_nodes_all{iteration} = nodes;
    Connectivity(iteration)= (1 / num_nodes) * rank(A);

    if ALG_NUM == 5 %Draw obstacles
         phi = 0:.1:2*pi;
         for k = 1:num_obstacles
            X = Rk(k)*cos(phi);
            Y = Rk(k)*sin(phi);
            plot(X+obstacles(k,1),Y+obstacles(k,2),'r',nodes(:,1),nodes(:,2),
                'g>')
            fill(X+obstacles(k,1),Y+obstacles(k,2),'r')
            axis([0 250 0 80]);
            hold on
         end
    end

    %================= PLOT and LINK SENSOR TOGETHER ===============
    plot(nodes(:,1),nodes(:,2), '.')
    hold on
    plot(nodes(:,1),nodes(:,2), 'k>','LineWidth',.2,'MarkerEdgeColor','k',
        'MarkerFaceColor','k','MarkerSize',5)
    hold off

    for node_i = 1:num_nodes
        tmp=nodes(Nei_agent{node_i},:);
        for j = 1:size(nodes(Nei_agent{node_i},1))
            line([nodes(node_i,1),tmp(j,1)],[nodes(node_i,2),tmp(j,2)])
        end
    end

    convergance = false;
    conv_val = nodes_va_next(1);
    for i = 2:num_nodes %check if converged within .001%
        if (conv_val - nodes_va_next(i)) < .001 %breaks if not in conscensus
            if i == 10
                convergance = true;
                nodes_va_f = conv_val; %set final converged estimate
            end
        end
    end

    if convergance == true
        break
    end

    history(iteration,:) = nodes_va_next; %add estimate to history
    nodes_va = nodes_va_next; %iterate estimates
    mov(iteration) = getframe;
    hold off
end



%===========================VIDEO SIMULATION=============================
%{
v = VideoWriter('flocking.avi', 'MPEG-4'); %Make movie
open(v)
writeVideo(v,mov);
%}
%=========================PLOT VELOCITY OF MSN===========================

p_each_nodes = [];
for i = 2:size(t,2) %iterates through the timesteps for the history cell matrix
    tmp7 = p_nodes_all{i};
    for j = 1:num_nodes
        if j == 1 %Plot velociy of sensor node 1; you can change this number to
            plot for other nodes
            p_each_nodes(i) = norm(tmp7(j,:));
            figure(3), plot(p_each_nodes, 'b')
            hold on
        end
    end
end

figure(4), plot(Connectivity)
grid on

%========================PLOT TRAJECTORY OF SENSOR NODES===============

for i = 2:length(q_nodes_all)
    tmp8 = q_nodes_all{i};
    figure(5), plot(tmp8(:,1), tmp8(:,2), 'k.')
    hold on
end

hold on
plot(nodes(:,1), nodes(:,2), 'm>', 'LineWidth', .2, 'MarkerEdgeColor', 'm',
    'MarkerFaceColor', 'm', 'MarkerSize', 5)

%========================PLOT TRAJECTORY OF COM AND TARGET===============

figure(6), plot(q_mean(:,1), q_mean(:,2),'k.')
hold on

if ALG_NUM ~= 1 || ALG_NUM ~= 2
    plot(qt1(:,1), qt1(:,2), 'r.')
end
```