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Problem 1

```
clc,clear,close

rng(623)
timesteps = 500;

V = diag([.03 .8*pi/180].^2);
P0 = diag([.01 .015 .1*pi/180].^2);

v = 1.5; %m/s
rp = RandomPath(20);

veh = Bicycle('covar',V);
veh.add_driver(rp);
veh.speedmax = 1.5; %m/s

ekf = EKF2(veh,V,P0);

% count = 0;
% for i=1:timesteps
%     ekf.step_man(v,0);
%     count = count + 1;
% end
% count

ekf.run(timesteps);

% t = zeros(1,timesteps);
% for i = 1:timesteps
%     t(i) = .1*i;
% end

x_est = [ekf.history.x_est]';

figure(1)
subplot(1,3,1)
hold on
%veh.plot_xy('--')
plot(veh.x_hist(:,1))
plot(x_est(:,1),'--r')
%plot(ekf.history.x_est(:,1))
xlabel('time')
ylabel('x (m)')
title('x vs time')
legend('Actual','Estimated')
hold off

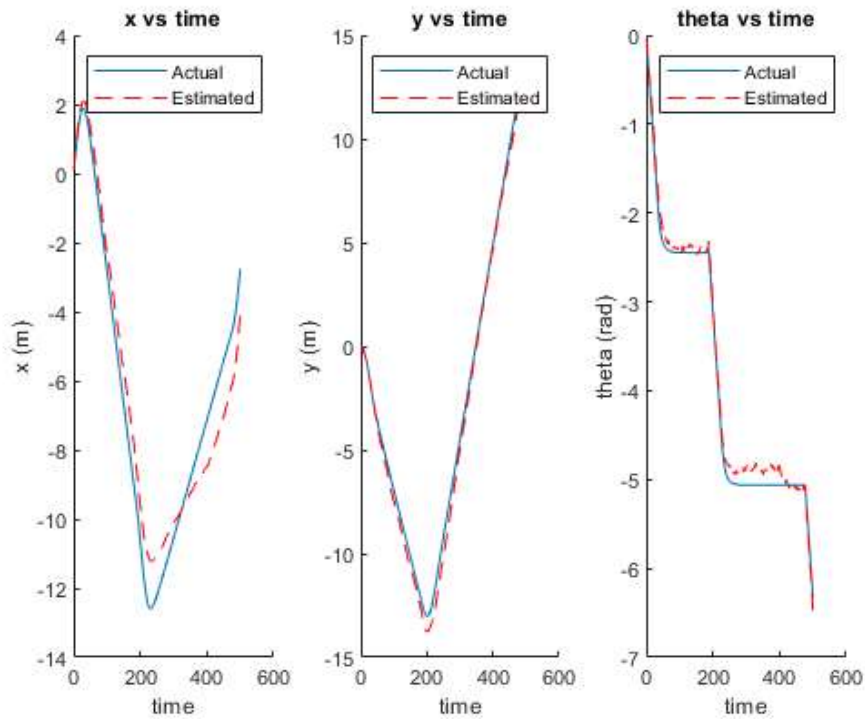
subplot(1,3,2)
hold on
%veh.plot_xy('--')
plot(veh.x_hist(:,2))
plot(x_est(:,2),'--r')
%plot(ekf.history.x_est(:,1))
xlabel('time')
ylabel('y (m)')
```

```

title('y vs time')
legend('Actual','Estimated')
hold off

subplot(1,3,3)
hold on
%veh.plot_xy('--')
plot(veh.x_hist(:,3))
plot(x_est(:,3),'--r')
%plot(ekf.history.x_est(:,1))
xlabel('time')
ylabel('theta (rad)')
title('theta vs time')
legend('Actual','Estimated')
hold off

```



Problem 2

```

clc,clear,close

rng(623)
timesteps = 500;

V = diag([.03 .8*pi/180].^2);
P0 = diag([.01 .015 .1*pi/180].^2);

v = 1.5; %m/s
rp = RandomPath(20);

veh = Bicycle('covar',V);
veh.add_driver(rp);
veh.speedmax = 1.5; %m/s

ekf = EKF2(veh,V,P0);

% count = 0;
% for i=1:timesteps
%     ekf.step_man(v,0);

```

```

%     count = count + 1;
% end
% count
figure(2)
ekf.run(timesteps);
close.figure(2))

figure(1)
hold on
ekf.plot_ellipse('b','interval',length(veh.x_hist)-1)

V = diag([.03 2*.8*pi/180].^2);
veh = Bicycle('covar',V);
veh.add_driver(rp);
veh.speedmax = 1.5; %m/s

ekf = EKF2(veh,V,P0);

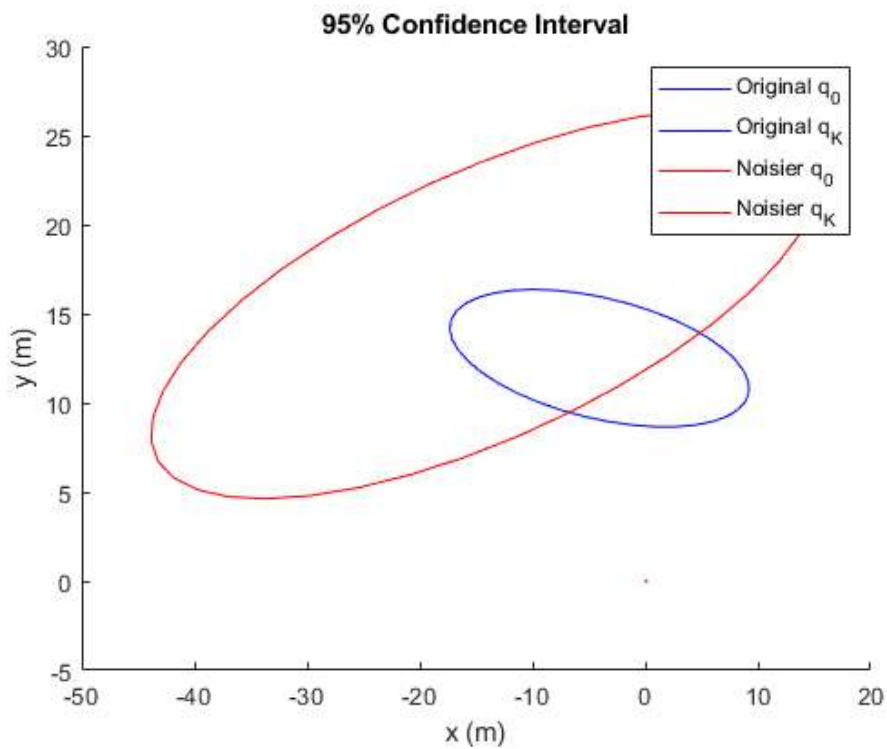
% hold off

figure(2)
ekf.run(timesteps);
close.figure(2))

% hold on

ekf.plot_ellipse('r','interval',length(veh.x_hist)-1)
xlabel('x (m)')
ylabel('y (m)')
title('95% Confidence Interval')
legend('Original q_0','Original q_K','Noisier q_0','Noisier q_K')
hold off

```



Problem 3

```

clc,close,clear

rng(2021)

```

```

V = diag([1/12 .5*pi/180].^2); %ft and rad

P0 = diag([10^-6 10^-6 10^-6].^2);

veh = Bicycle('covar',V);

speed = 40; %mph

speed = speed*(5280/3600); %ft/s
steering_angle = 0;

ekf = EKF2(veh,V,P0);

inLane = 1;
count = 0;
while inLane
odo = ekf.step_man(speed,steering_angle);
count = count + 1;

std_y = sqrt(ekf.P_est(2,2));

if ekf.x_est(2) + 2*std_y >= 2 || ekf.x_est(2) - 2*std_y <= -2
    inLane = 0;
end

end

end_time = length(ekf.history)*veh.dt;

fprintf('Part a)\nIt took the vehicle %.2f seconds for the 95% confidence interval to leave the 2ft bound\n',end_time)

```

Part a)

It took the vehicle 11.50 seconds for the 95% confidence interval to leave the 2ft bound

Problem 3 Part b

```

clc,clear,close

end_times = zeros(1,100);

for i=1:100

rng(round(rem(now,1)*10^8))

V = diag([1/12 .5*pi/180].^2); %ft and rad

P0 = diag([10^-6 10^-6 10^-6].^2);

veh = Bicycle('covar',V);

speed = 40; %mph

speed = speed*(5280/3600); %ft/s
steering_angle = 0;

ekf = EKF2(veh,V,P0);

inLane = 1;
count = 0;
while inLane
odo = ekf.step_man(speed,steering_angle);
count = count + 1;

```

```
std_y = sqrt(ekf.P_est(2,2));

if ekf.x_est(2) + 2*std_y >= 2 || ekf.x_est(2) - 2*std_y <= -2
    inLane = 0;
end

end

end_times(i) = length(ekf.history)*veh.dt;
end

filtered_end_times = end_times(end_times >= 11.5); %takes out all simulations that failed before 11.5 seconds

num_passed = length(filtered_end_times);

percent_passed = num_passed/100;

fprintf('Part b)\n%.2i of the simulations were not out of bounds by 11.5 seconds\n',num_passed)
```

Part b)
80 of the simulations were not out of bounds by 11.5 seconds