Assignment 3 Determining and removing drawbacks of exponential and running mean

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Part II

SECOND TRAJECTORY

```
clc;
clear all;
close all;
```

T1: Generate a true trajectory

```
n=200;
T=32;
w = 2*pi/T;
X= zeros(n,1);
w_var = 0.08^2;
A = zeros(n,1);

A(1)=1;
noise = sqrt(w_var)*randn(n);

for i=2:n
    A(i)=A(i-1)+noise(i);
    X(i) = A(i)*sin(w*i+3);

end
```

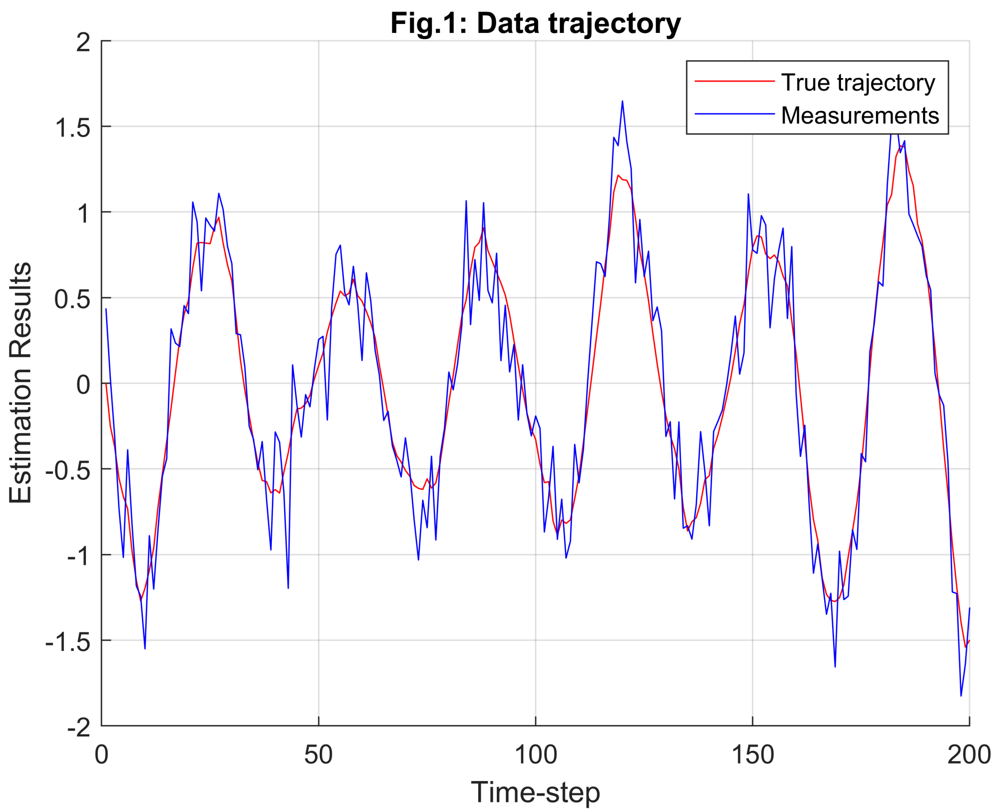
T2: Generate measurements

```
n_var=0.05;

z=zeros(n,1);
neta= sqrt(n_var)*randn(n,1);

z=X+neta;
```

```
figure
hold on
plot(X,'r')
plot(z,'b')
title('Fig.1: Data trajectory')
legend('True trajectory','Measurements')
xlabel('Time-step')
ylabel("Estimation Results")
grid on
```

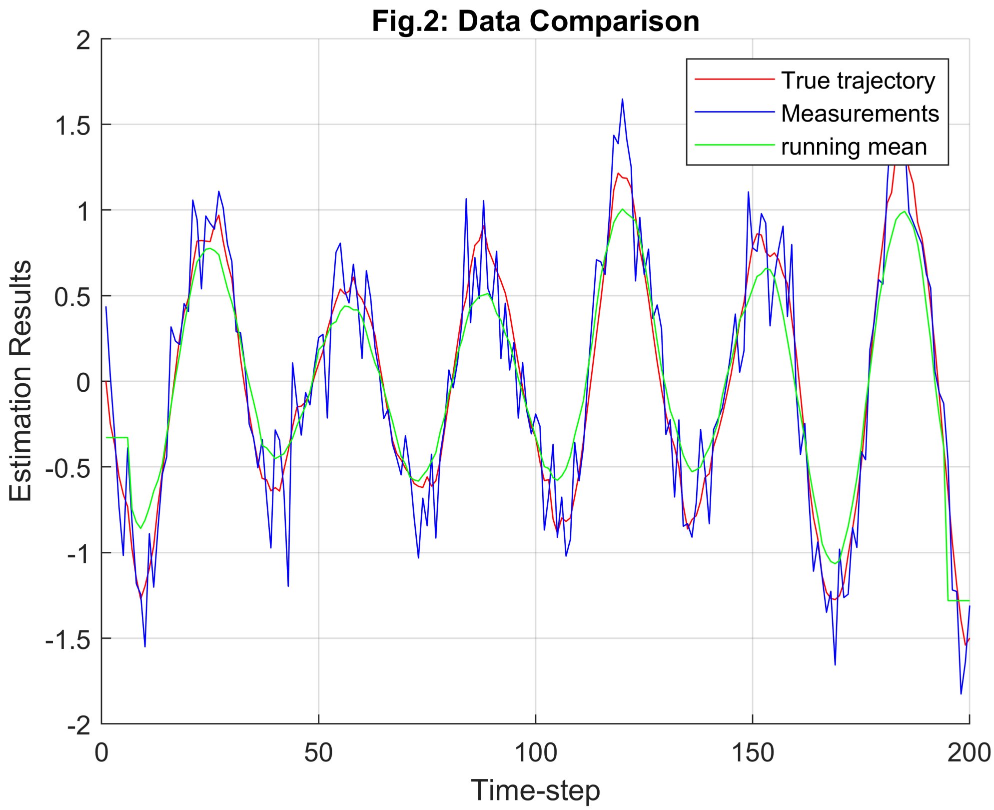


T3: Apply running mean with window size M = 13

```
M=13;
win=floor((M-1)/2);
X_rm=zeros(n,1);
for i=win+1:n-win
   sumZ =sum(z(i-win:i+win,1));
   X_rm(i,1)=1/M*sumZ;
end
X_rm(1:win,1)=sum(z(1:win,1))/win;
X_rm(n-win+1:n,1)=sum(z(n-win+1:n,1))/win;

figure
hold on
plot(X,'r')
plot(z,'b')
plot(X_rm,'g')
title('Fig.2: Data Comparison')
legend('True trajectory','Measurements','running mean')
```

```
xlabel('Time-step')
ylabel("Estimation Results")
grid on
```



T4: Determine period of oscillation, M = 25

```
size1 = 200;
A=zeros(size1,1);
x=zeros(size1,1);
A(1)=1;

% a) T<M
% b) T=M (+- 1 point)
% c) T>M, T>2m'
```

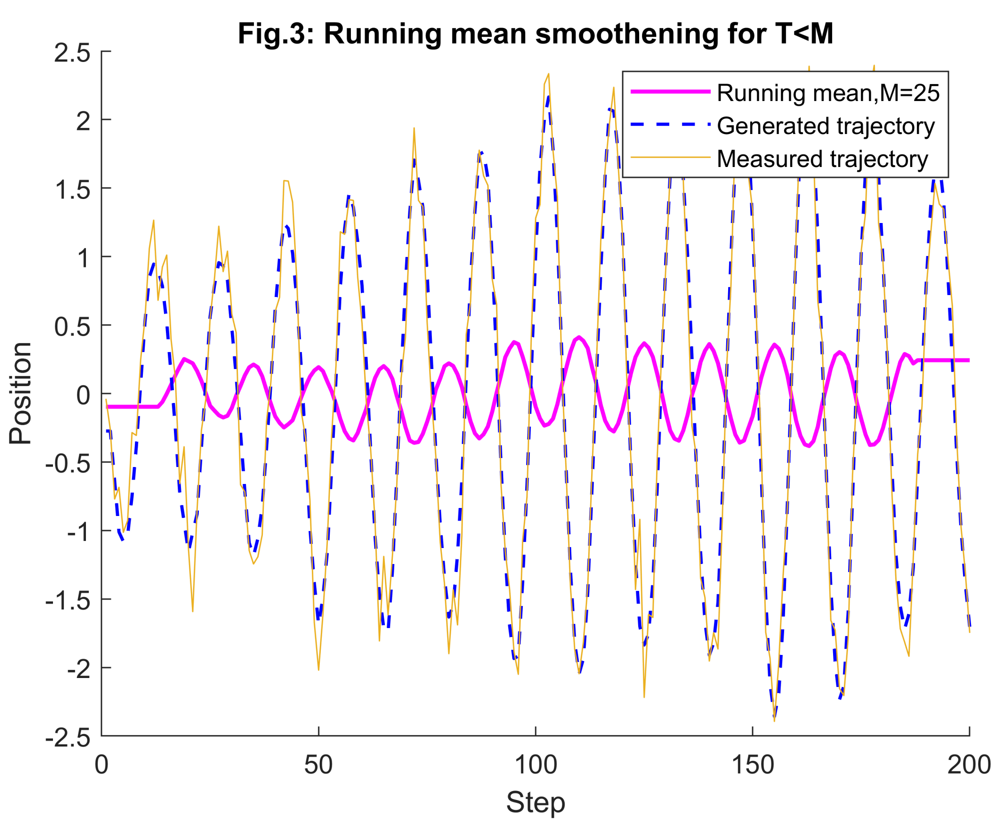
When T<M i.e. Inverse oscillations

```
T=15;
omega=2*pi/T;
var_w=0.08^2;
sigma_w=sqrt(var_w);
x(1)=A(1)*sin(omega+3);
w=randn(size1,1)*sigma_w;
%% Trajectory generation
for i = 1:size1-1
    x(i+1)=A(i)*sin(omega*i+3);
    A(i+1)=A(i)+w(i+1);
end
```

```
%% Measurement generation
var_n=0.05;
sigma_n=sqrt(var_n);
n=randn(size1,1)*sigma_n;
z=x+n;
M = 25;
win=floor((M-1)/2);
XfRm=zeros(size1,1);

for i=win+1:size1-win-1
   sumZ =sum(z(i-win:i+win));
   XfRm(i)=1/M*sumZ;
end
XfRm(1:win)=sum(z(1:win,1))/win;
XfRm(size1-win:size1,1)=sum(z(size1-win:size1))/win;


figure
hold on
plot(XfRm,"m","linewidth",1.5)
plot(x,'b--','Linewidth',1.2)
plot(z)
legend("Running mean,M=25","Generated trajectory","Measured trajectory")
title("Fig.3: Running mean smoothening for T<M")
xlabel("Step")
ylabel("Position")
```



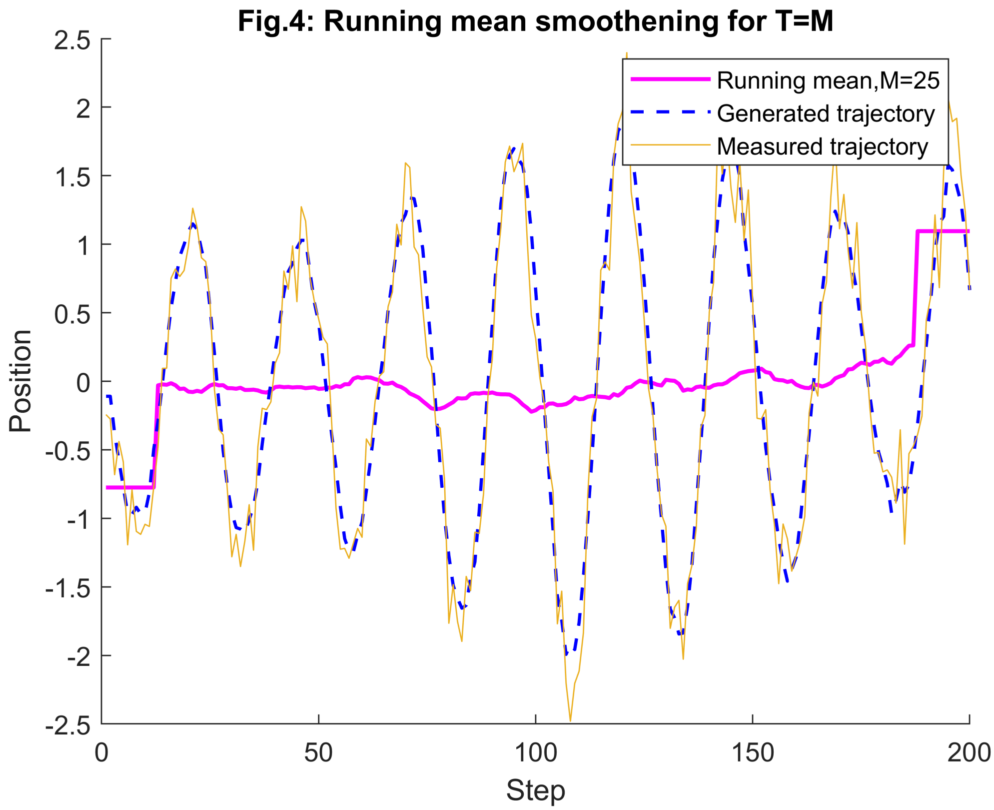
When T=M i.e. loss of oscillations

```
T=25;
omega=2*pi/T;
var_w=0.08^2;
sigma_w=sqrt(var_w);
x(1)=A(1)*sin(omega+3);
w=randn(size1,1)*sigma_w;
%% Trajectory generation
for i = 1:size1-1
    x(i+1)=A(i)*sin(omega*i+3);
    A(i+1)=A(i)+w(i+1);
end

%% Measurement generation
var_n=0.05;
sigma_n=sqrt(var_n);
n=randn(size1,1)*sigma_n;
z=x+n;
M = 25;
win=floor((M-1)/2);
XfRm=zeros(size1,1);

for i=win+1:size1-win-1
   sumZ =sum(z(i-win:i+win));
   XfRm(i)=1/M*sumZ;
end
XfRm(1:win)=sum(z(1:win,1))/win;
XfRm(size1-win:size1,1)=sum(z(size1-win:size1))/win;


figure
hold on
plot(XfRm,"m","linewidth",1.5)
plot(x,'b--','Linewidth',1.2)
plot(z)
legend("Running mean,M=25","Generated trajectory","Measured trajectory")
title("Fig.4: Running mean smoothening for T=M")
xlabel("Step")
ylabel("Position")
```



When T>M i.e. change in oscillations insignificantly

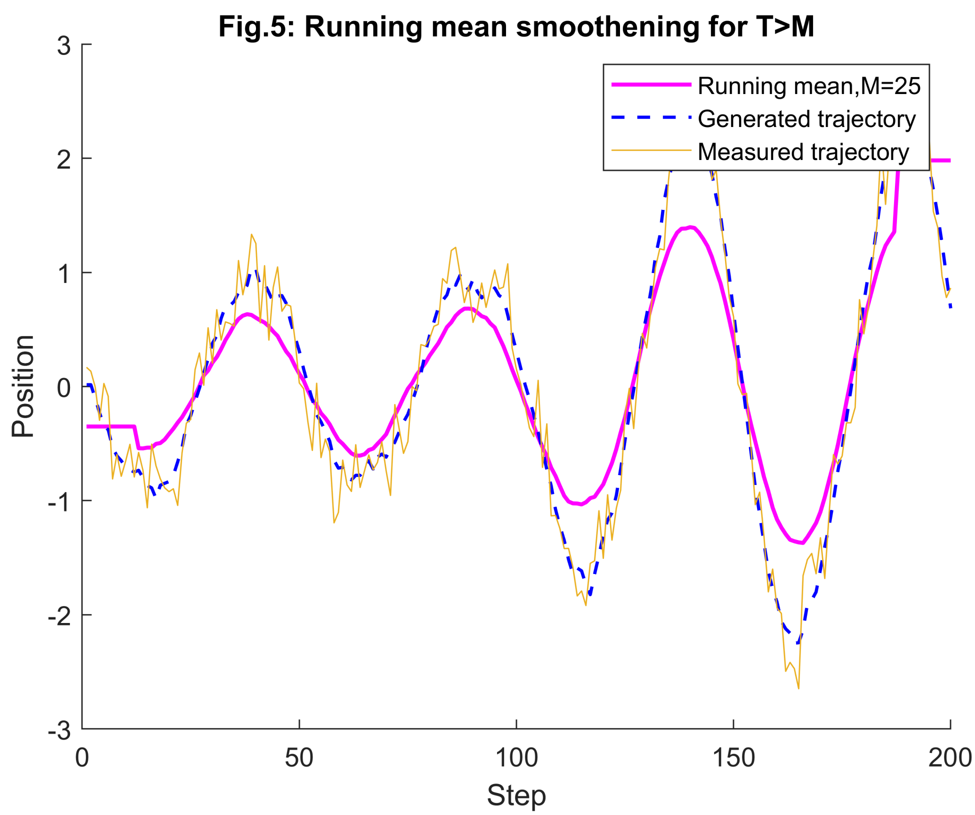
```
T=50;
omega=2*pi/T;
var_w=0.08^2;
sigma_w=sqrt(var_w);
x(1)=A(1)*sin(omega+3);
w=randn(size1,1)*sigma_w;
%% Trajectory generation
for i = 1:size1-1
    x(i+1)=A(i)*sin(omega*i+3);
    A(i+1)=A(i)+w(i+1);
end

%% Measurement generation
var_n=0.05;
sigma_n=sqrt(var_n);
n=randn(size1,1)*sigma_n;
z=x+n;
M = 25;
win=floor((M-1)/2);
XfRm=zeros(size1,1);

for i=win+1:size1-win-1
   sumZ =sum(z(i-win:i+win));
   XfRm(i)=1/M*sumZ;
end
XfRm(1:win)=sum(z(1:win,1))/win;
```

```
XfRm(size1-win:size1,1)=sum(z(size1-win:size1))/win;


figure
hold on
plot(XfRm,"m","linewidth",1.5)
plot(x,'b--','Linewidth',1.2)
plot(z)
legend("Running mean,M=25","Generated trajectory","Measured trajectory")
title("Fig.5: Running mean smoothening for T>M")
xlabel("Step")
ylabel("Position")
```



Conclusions:

- Running mean smoothing provides the smoothened trajectory which is quite close to the true one. Though it has artifacts in first and last (m-1)/2 points.
- Determine period of oscillation:
- a) When M>T, the average of one period+small part is calculated.For period average of sinus equals to 0, for small part - not 0, so the resulted trajectory has much smaller amplitude than the initial one. The phase of oscillations inverses also because of this small part.
- b) the average value of sinus for one period equals to 0. When M=T, this average is calculated, so there is no sinus form in smoothened trajectory.
- c) When M is less or significantly less than period, RM can't affect the sinus, because it averages only a tiny part of it. But it decreases the amplitude.