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%%% Laboratory work # 11
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%%% Noise statistics identification to construct tracking filter of a moving object
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% Part 1
% trajectory generation
close all;
clear;
N = 500000;
T=1;
v1=1;
sigmaA=3;
sigmaN=10;
x1=5;
q = 6;
t=1:N;
[x, z] = trajgen_acc(x1, sigmaN, sigmaA, N, T, v1, q);

figure(1)
plot(t,x, t,z)
xlim([t(1), 10])
ylim([x(1), 100])

[sA,sN,qz] = getstat(z,T);
```

Based on measurements: $\sigma_a = 2.9838,\ \sigma_\eta = 9.9984,\ q = 5.9966$

Real parameters: $\sigma_a = 3,\ \sigma_\eta = 10,\ q = 6$

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% Part 2
N = 200;
[x, z] = trajgen_acc(x1, sigmaN, sigmaA, N, T, v1, q);
% state space - form of equations
[F,G,H] = state_space(T);
% initial covariance matrix
P0 = [1e10 0; 0 1e10];
X0 = [2;0];
R = sN^2;
Q = G*G'*sA^2;

[~,~,Xfl,Pfl,K] = kalman_filter_bias(X0,P0,F,Q,H,R,G,z,qz);
```
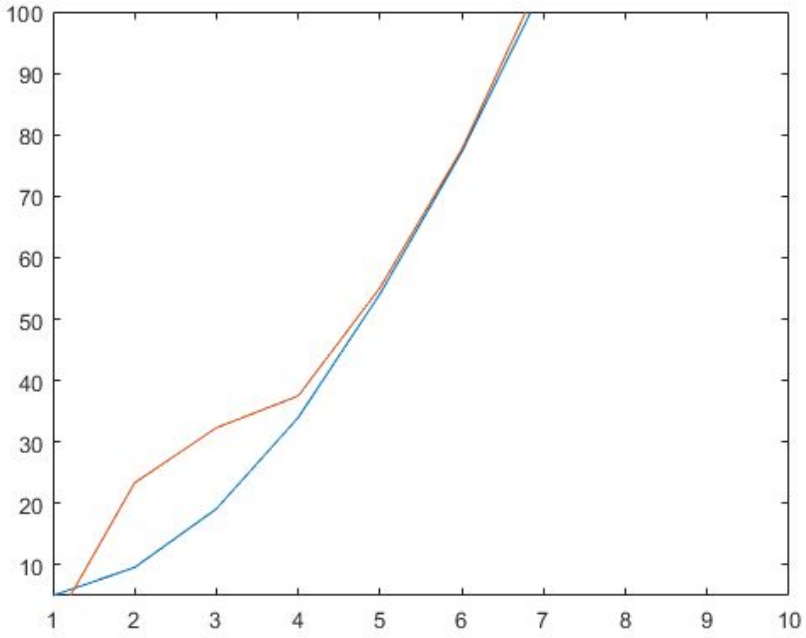
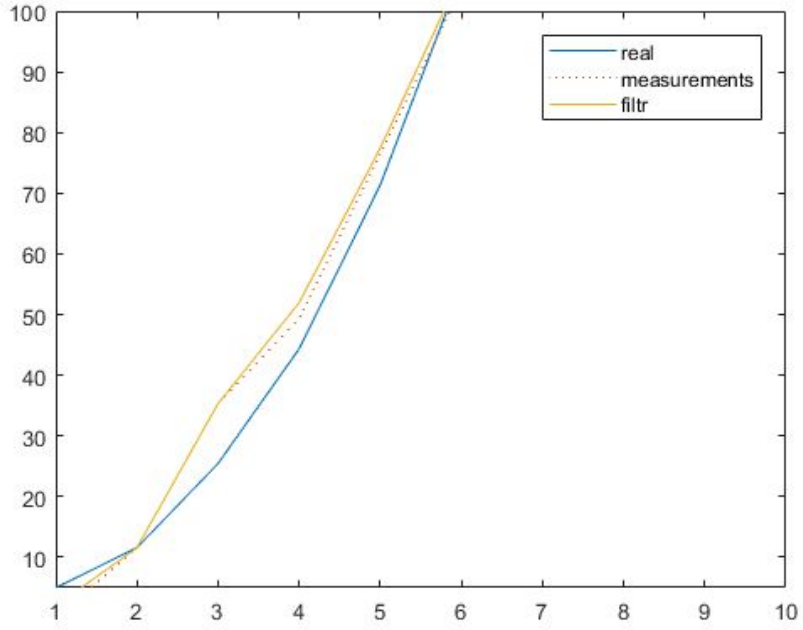

```
p = nan(1,N);
for i=1:(N-1)
    p(i) = sqrt(Pfl{i}(1,1));
end

t=1:N;
figure(2)
plot(t,x, t,z,':', t,Xfl(1,:));
xlim([t(1), 10])
ylim([x(1), 100])
legend('real', 'measurements', 'filtr')

% final error
% generation of M=500 realiztions of trajectories
M=500;
X = cell(1,M);
Z = cell(1,M);
for i=1:M
    [X{i}, Z{i}] = trajgen_acc(x1, sigmaN, sigmaA, N, T, v1, q);
end
% Kalman-filtration of generated trajectories
Xfl_ = cell(1,M);
xfl = cell(1,M);
Pfl = cell(1,M);
for i=1:M
    [~,~,Xfl_{i},~,~] = kalman_filter_bias(X0,P0,F,Q,H,R,G,Z{i},qz);
    xfl{i} = Xfl_{i}(1,:);
end

fe = final_error(xfl, X);

figure(3)
plot(t,fe, t,p);
legend('final error', 'standart deviation');
ylabel('Final error')
xlabel('Time step')
ylim([5,20])
title('Comparison of errors')
grid on;
```

Estimated parameters of noise and bias are very close to real ones.

Real trajectory and measurements



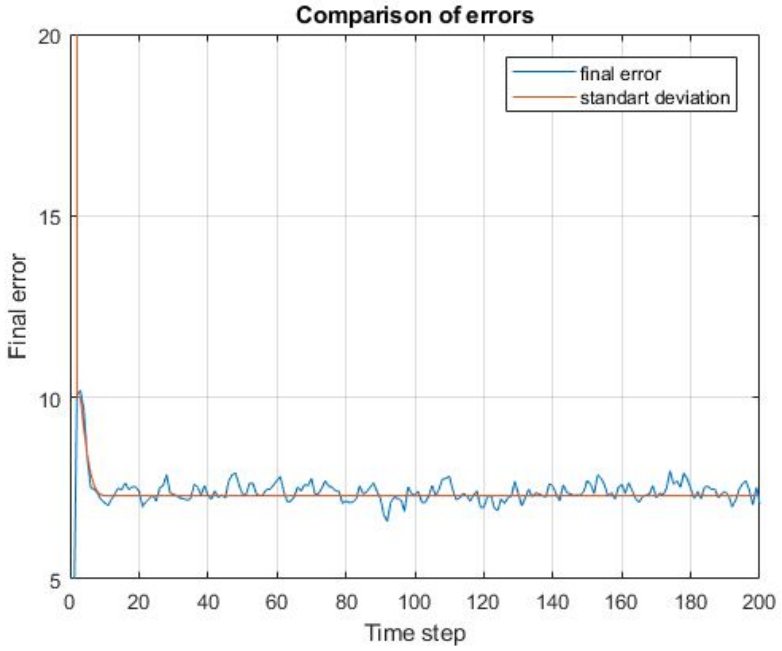
Real trajectory, measurements and filtered trajectory for short period of time



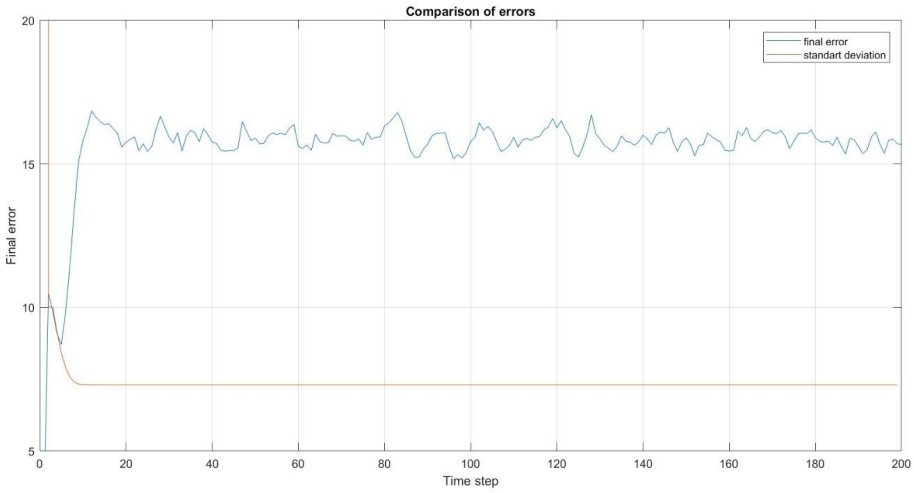
estimated	N=500	N=5 000	N=50 000	N=500 000	N = 5 000 000

params					
sA (real sA = 3)	3.3061	3.8284	2.6721	2.9984	3.0309
sN (real sN = 10)	9.8811	9.9134	10.0541	9.9926	9.9995
q (real q = 6)	6.0149	6.0031	5.998	6.0037	5.9979

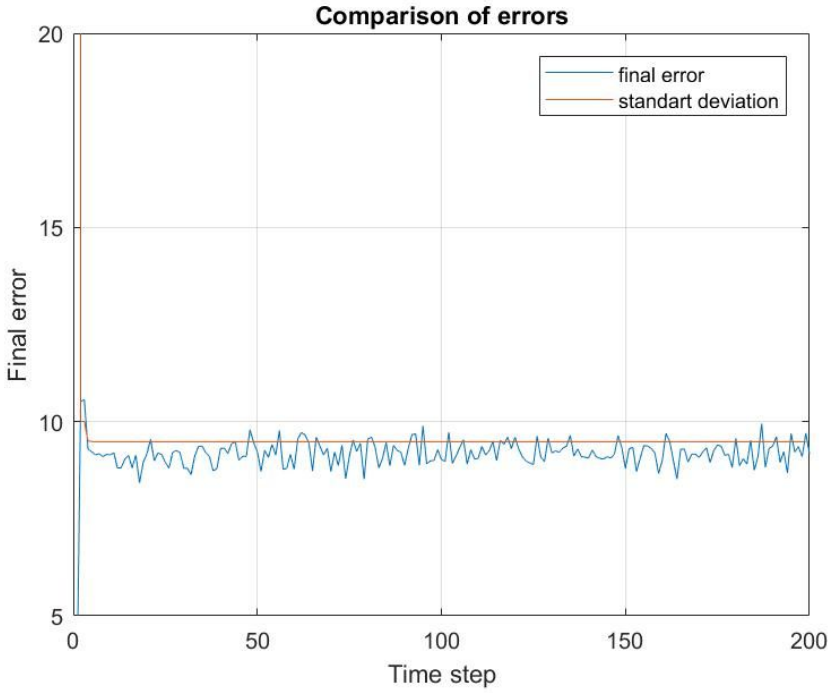
3) Applying filter to M=500 trajectories and comparison of true estimation error of coordinate xi with errors of estimation $Pi.i$ provided by Kalman filter algorithm.



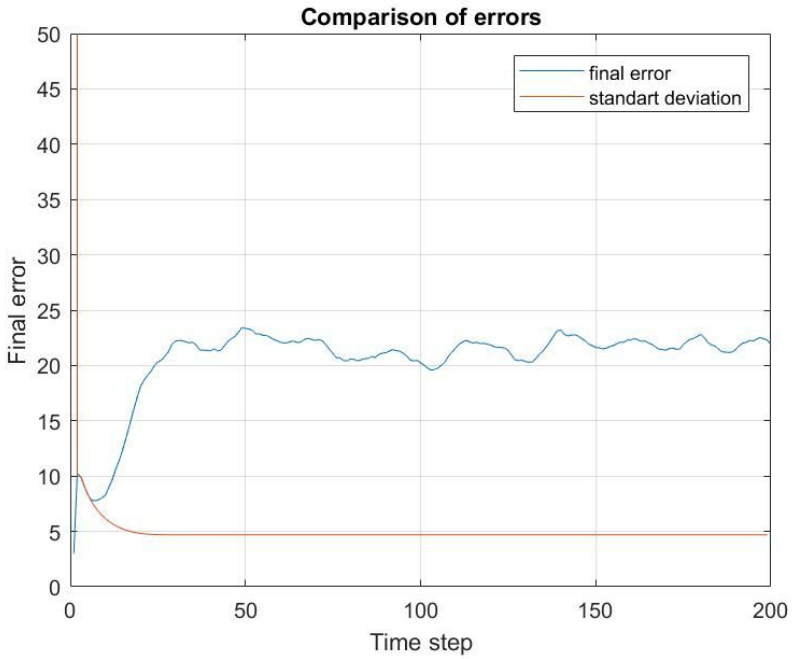
4) Changing the values of noise statistics and analyzing sensitivity of Kalman filter output to these changes.



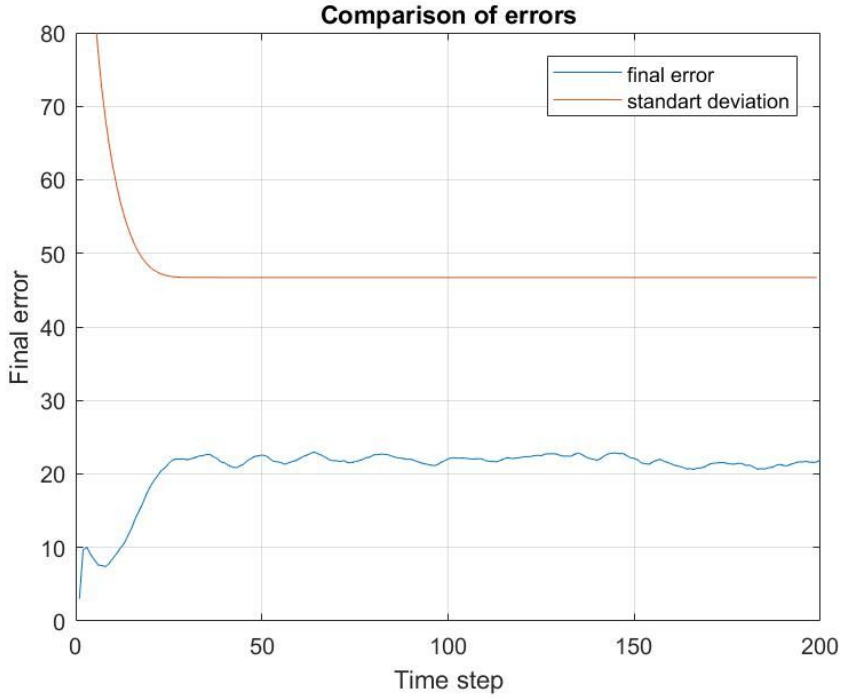
4a) q=0;



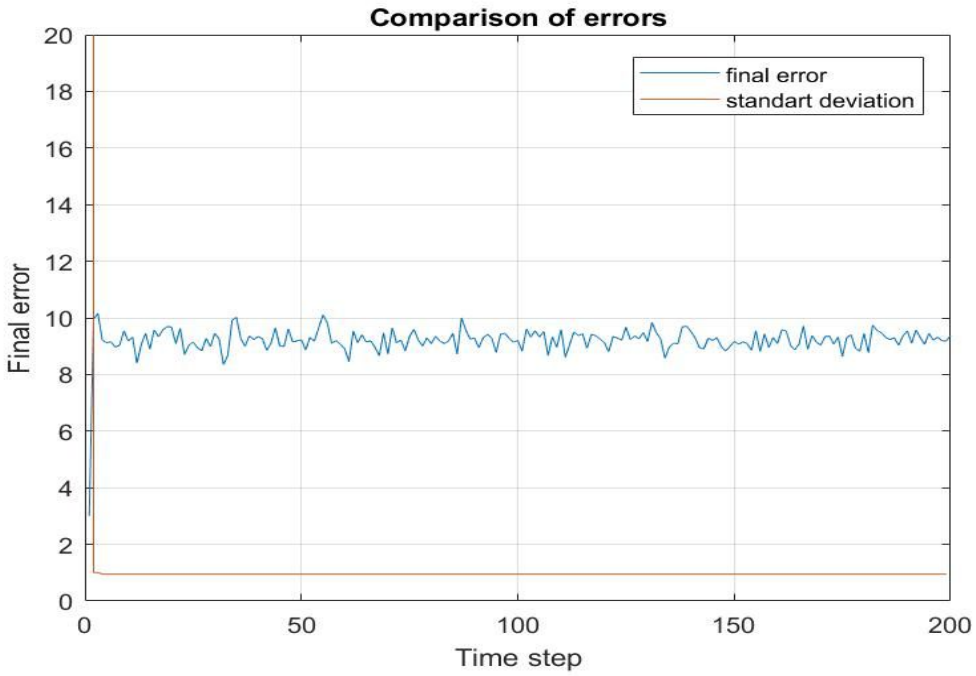
4b) $\sigma_a = 10\sigma_a$;



4c) $\sigma_a = \sigma_a/10$;



4d) $\sigma_n = 10\sigma_n$;



4e) $\sigma_n = \sigma_n/10$

Conclusion. Sensitivity of filter is depend on accuracy of estimation of noise parameters.

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