Ass5 Neuromechanics And Motor Control

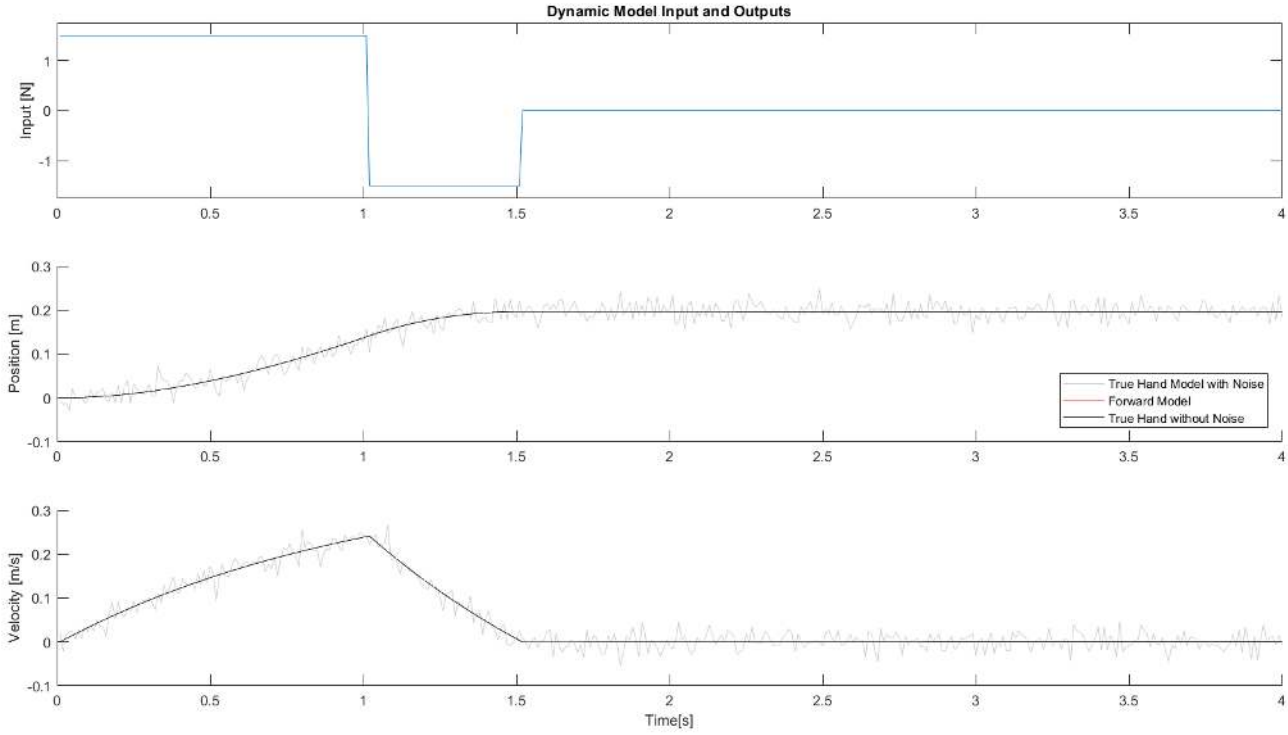
Neuromechanics & Motor Control (Technische Universiteit Delft)

BM41040 – Neuromechanics & Motor Control

Defining a Movement

Question 2

b) Plot the input force F and the resulting movement



The Kalman Filter

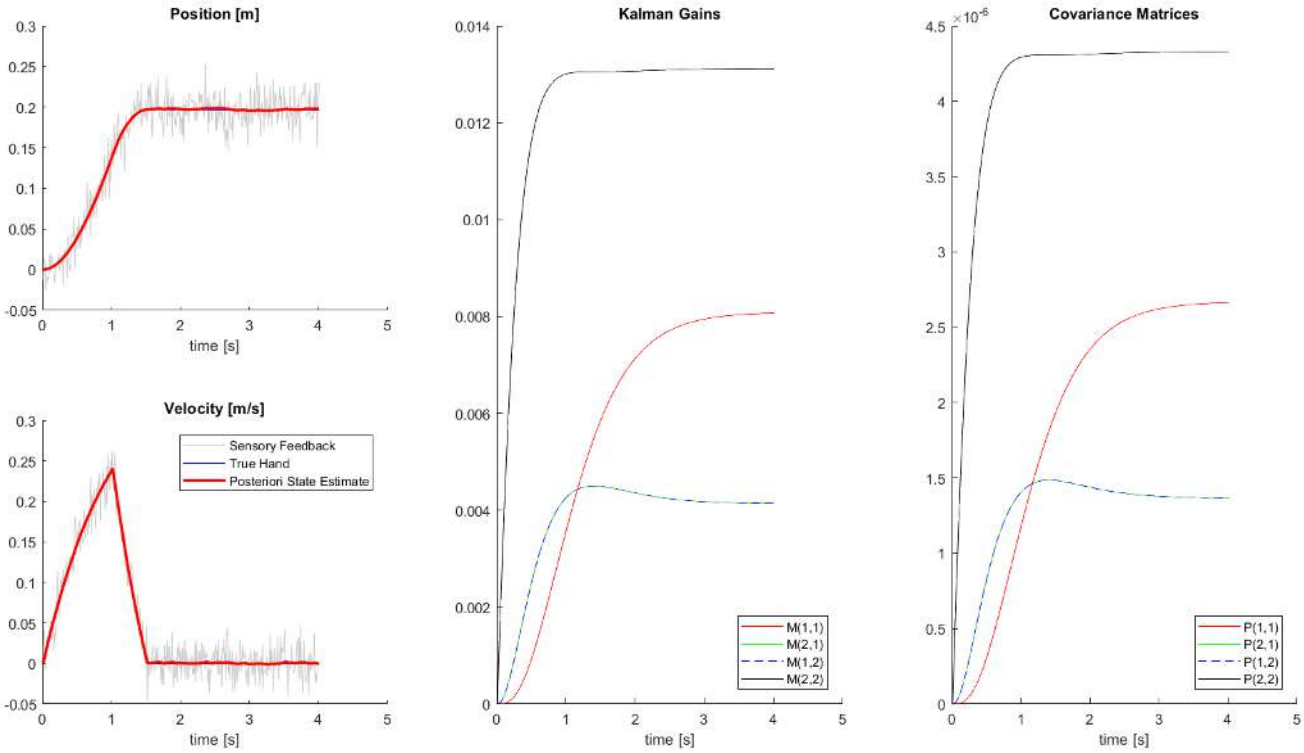
Question 3

a) Code of the Kalman filter

```
function [MArray, xPrioriArray, xPosterioArray, pPosterioArray] =
as5_kf_kalman(ForwardModel,NoiseModel,params,models,data)
%% Function containing the Kalman Filter Equations

%% 1) Define Matrices needed for Kalman Filter
u = data.u;
A = ForwardModel.A;
B = ForwardModel.B;
C = ForwardModel.C;

Q = params.Q;

R = params.R;
nSample = length(u);
N = size(C,2);

k = 1:nSample;
t = params.t;
```

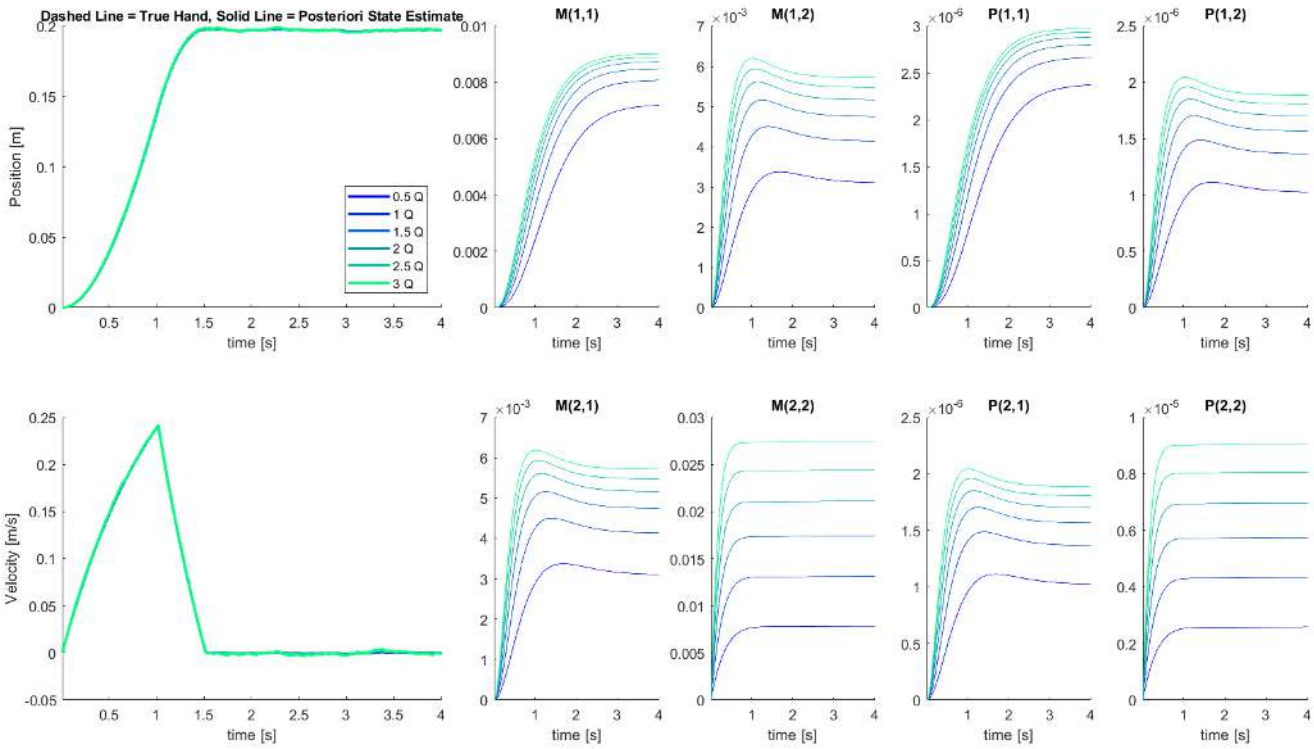
```
Q = [Q, zeros(N,N-2);zeros(N-2,N)];
Zk = data.yNoise;

%% 2) Preallocation (reserving space) of matrices to speed up
calculations
M    =       zeros(N);
xPriori   =       zeros(N);
% xPosterioArray  =       zeros(nSample,2);
% pPosterioArray  =       zeros(nSample,2,2);

%% 3) Initialize Covariance and State Estimates
xPosterio  = zeros(N);
pPosterio  = zeros(N);

%% 4) Run the Kalman Filter

for i = 2:nSample
    xprior = A*xPosterio+B*u(i-1);
    Pprior = A*pPosterio*A.'+ Q;
    xPrioriArray(i,:) = xprior(1:2);

    M = Pprior*C.'/(C*Pprior*C.'+R);
    MArray(i,:,:) = M(1:2,1:2);

    xPosterio = xprior + M*(Zk(i,:).'-C*xprior);
    xPosterioArray(i,:)  = xPosterio(1:2);

    pPosterio =  Pprior - M*C*Pprior;
    pPosterioArray(i,:,:) = pPosterio(1:2,1:2);
end
end
```

b) Simulate the movement and estimate hand position with the Kalman filter - plot

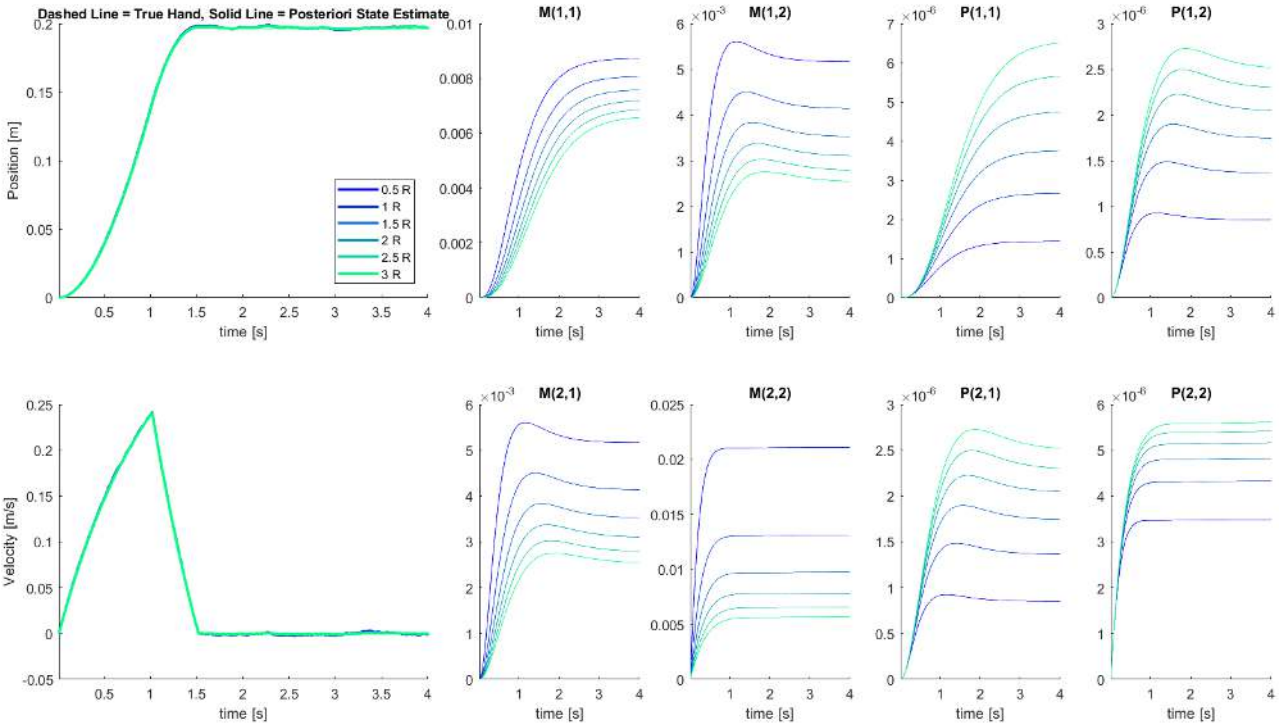


Investigate the Effect of Different Parameters on the Kalman Filter Estimate
Question 4

a) Investigate the effect of different levels of Q



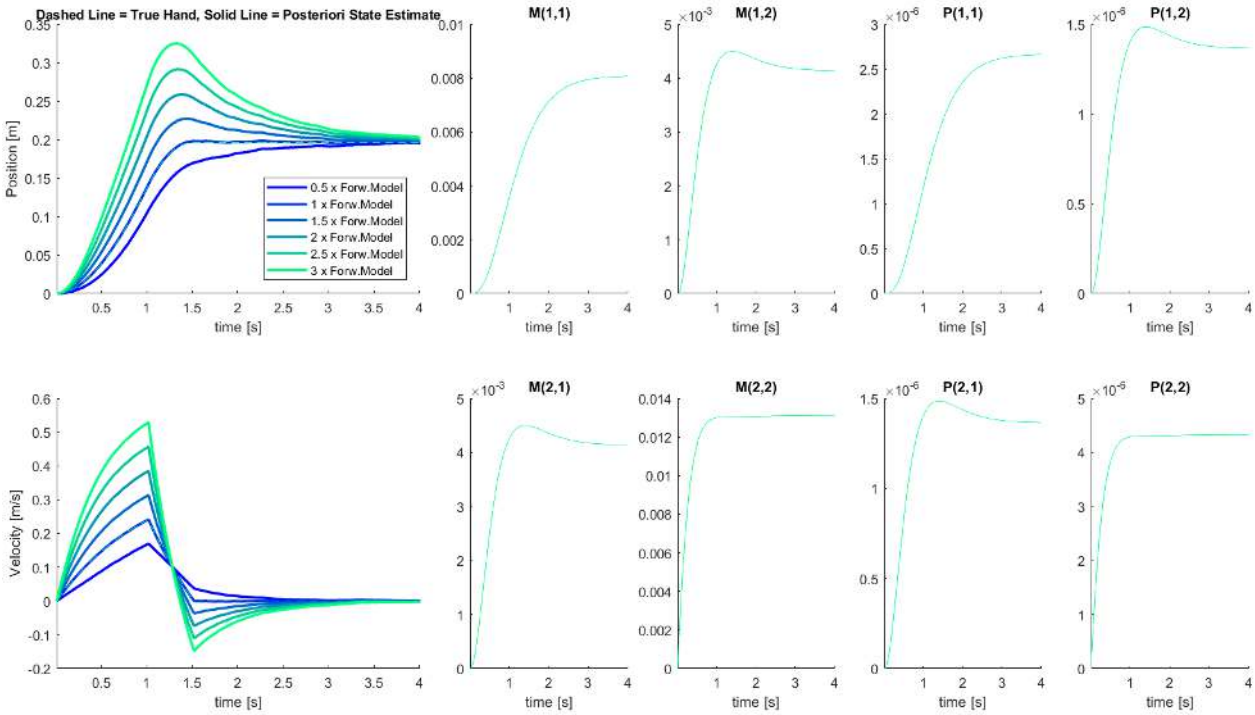
b) Investigate the effect of different levels of R



Investigate the Effect of an Incorrect Forward Model

Question 5

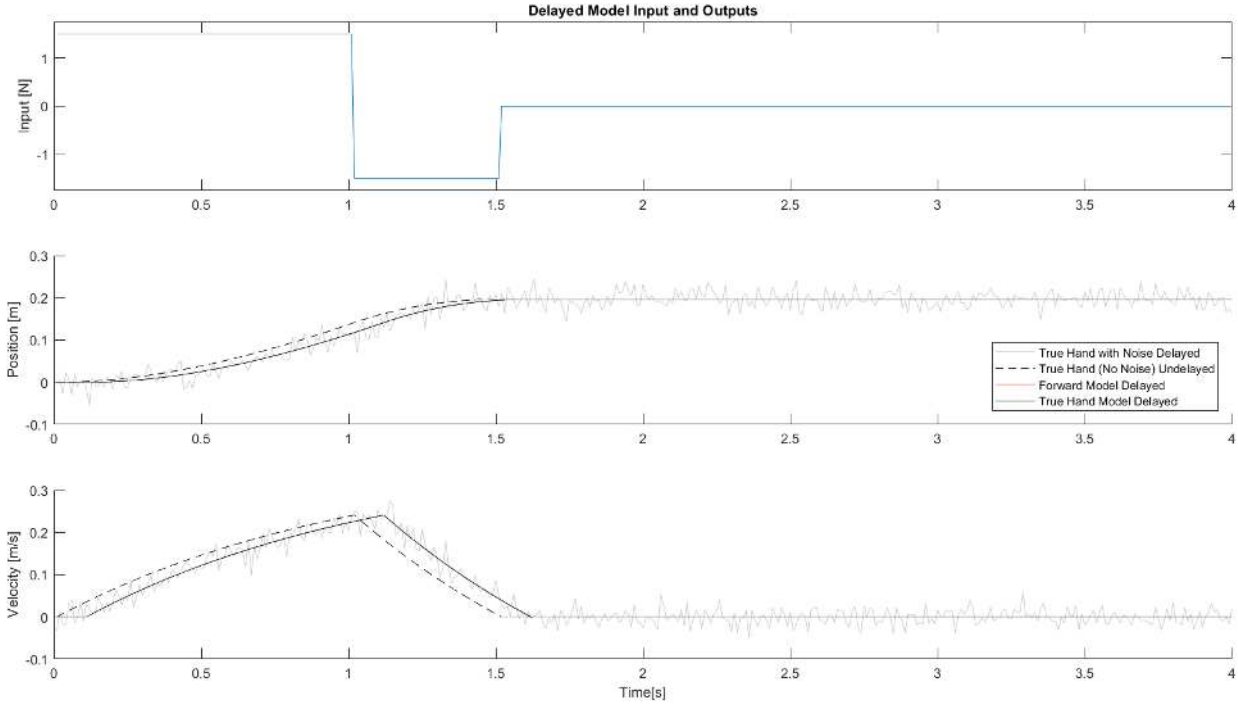
a) Investigate the effect of different levels for *g*



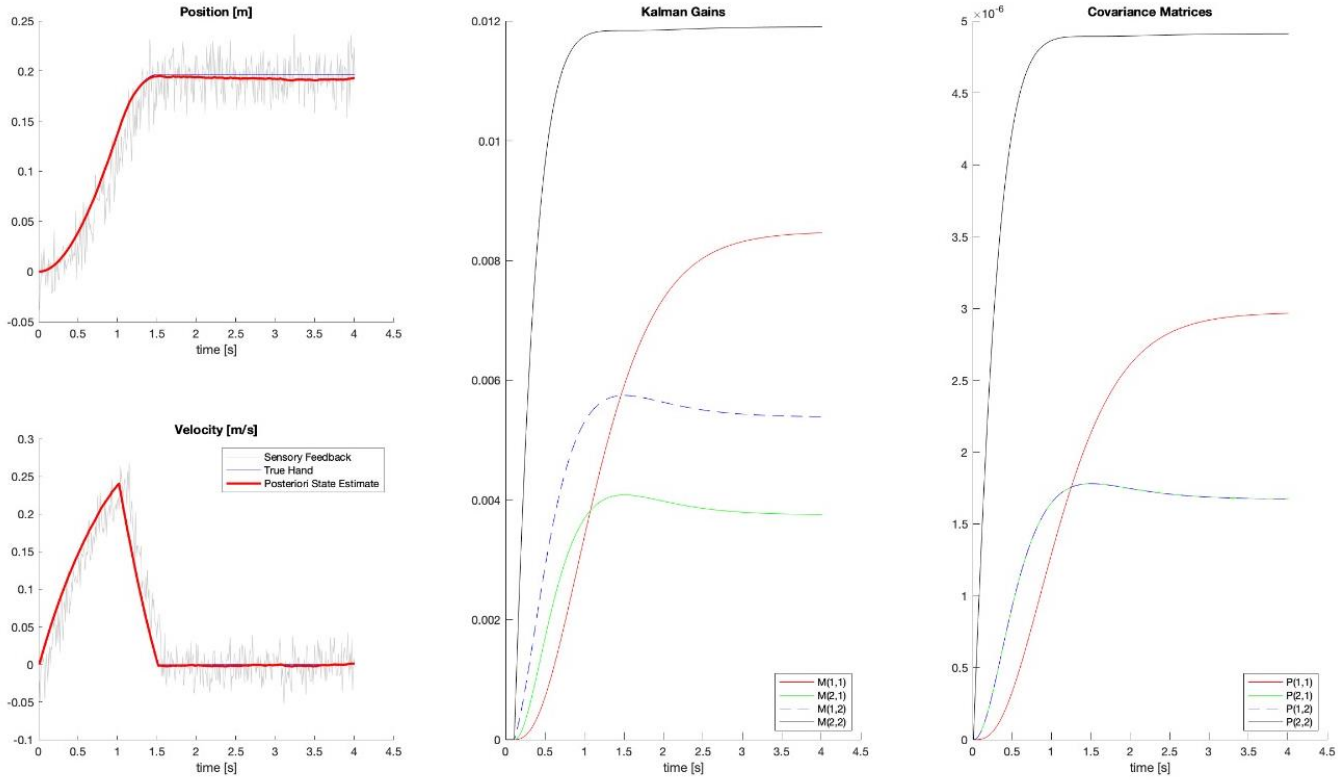
Incorporating a Time Delay

Question 6

a) Plot of the delayed movement



b) Kalman filter with the delayed model



c) Come up with an experiment to validate whether the brain uses the same update mechanisms to obtain the a-posteriori state estimate, given delayed feedback of body state.

We need an experiment where we compare the observational measures and the Kalman filter prediction of the brain mechanism in the same situation. There is a natural occurrent time delay, but we can add another delay, for example in a reaching movement where the hand has to reach a target and we have a visual feedback of it, the experimental set up can include a screen where the subject watches his/her hand not in real-time but after the additional time delay. The Kalman filter can correct both the delays (natural and additional) and give the results of the state estimate, that are compared with the observation and if they are similar we can say the Kalman filter is a good representation of the brain mechanisms.