

# Assignment\_3\_KF

May 6, 2025

## 0.0.1 Unscented Kalman filter (Non-Linear Kalman) Algorithm

#Process model

$$\dot{\mathbf{x}} = \begin{bmatrix} \dot{\mathbf{p}} \\ G(\mathbf{q})^{-1}(\mathbf{u}_\omega - \mathbf{b}_g) \\ \mathbf{g} + R(\mathbf{q})(\mathbf{u}_a - \mathbf{b}_a) \\ \mathbf{n}_{bg} \\ \mathbf{n}_{ba} \end{bmatrix}$$

### Predict Step

#### 1. Sigma Point Generation

Generate a set of sigma points around the current state mean using the state covariance matrix. These points are deterministically chosen to capture the mean and covariance of the state distribution.

#### 2. Process Model Propagation

Each sigma point is propagated through the nonlinear process model to predict the future state. This step captures the nonlinearity in the system dynamics.

#### 3. Predicted Mean and Covariance

The predicted state mean and covariance are computed as a weighted average of the propagated sigma points. This forms the prior estimate for the current time step.

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### Update Step

#### 1. Sigma Points in Measurement Space

The predicted sigma points are passed through the nonlinear observation model to map them into the measurement space.

#### 2. Predicted Measurement and Covariance

Compute the predicted measurement mean and covariance using a weighted average of the transformed sigma points.

#### 3. Cross-Covariance Calculation

Compute the cross-covariance matrix between the state space and the measurement space sigma points.

#### 4. Kalman Gain Computation

Calculate the Kalman gain using the cross-covariance and the predicted measurement co-

variance. This gain determines how much the prediction should be corrected based on the measurement.

#### 5. State and Covariance Update

Update the state estimate and state covariance using the actual measurement, the predicted measurement, and the Kalman gain.

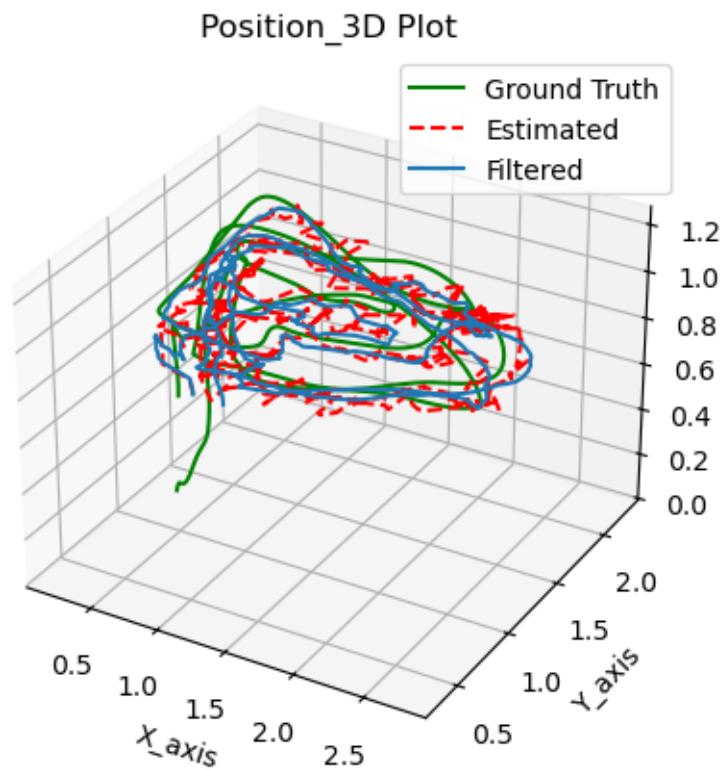
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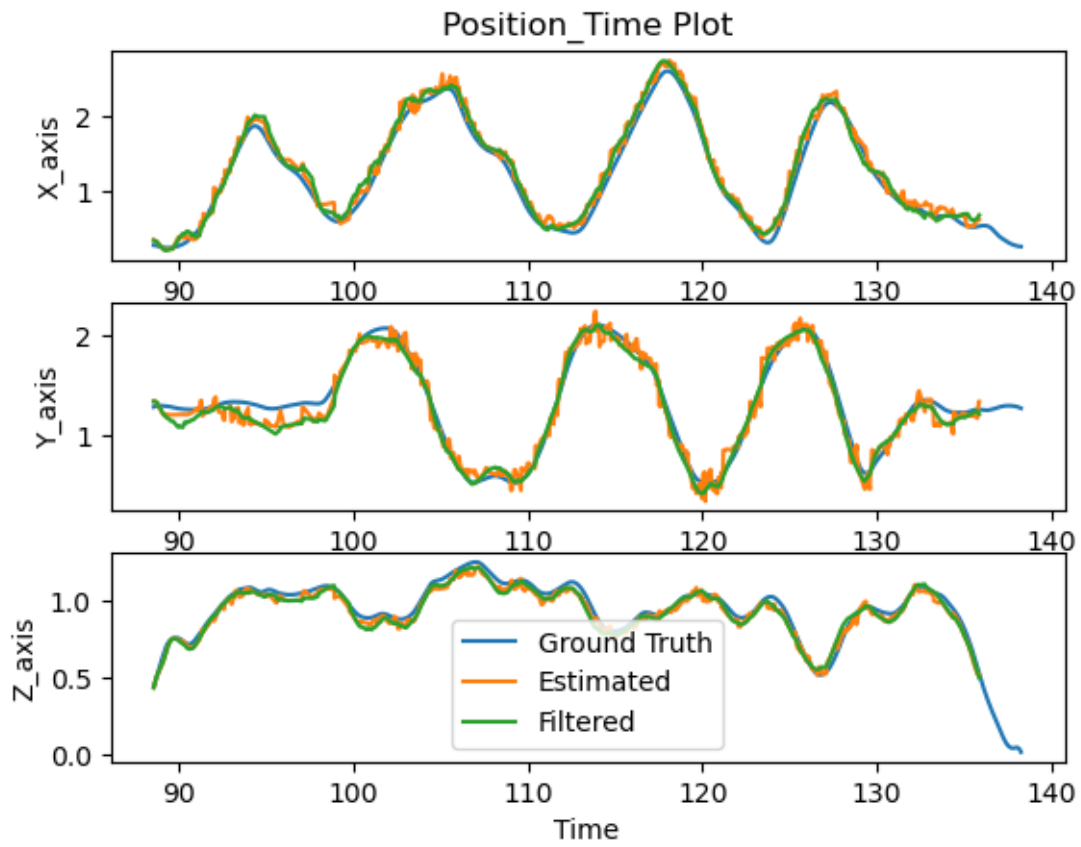
#### 0.0.2 Plots

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[ ]: #Simulate the results and plot

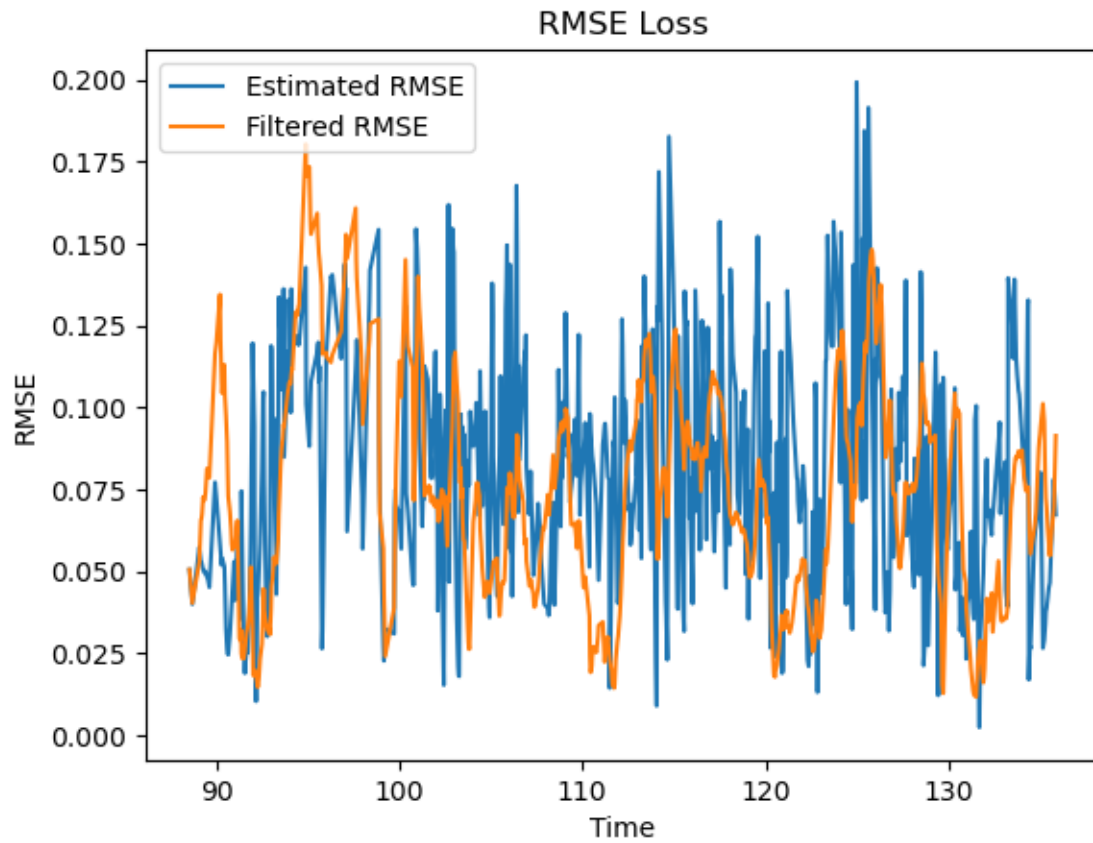
from simulation_KF import simulate

filename = "data\data\studentdata0.mat"
simulate(filename)
```

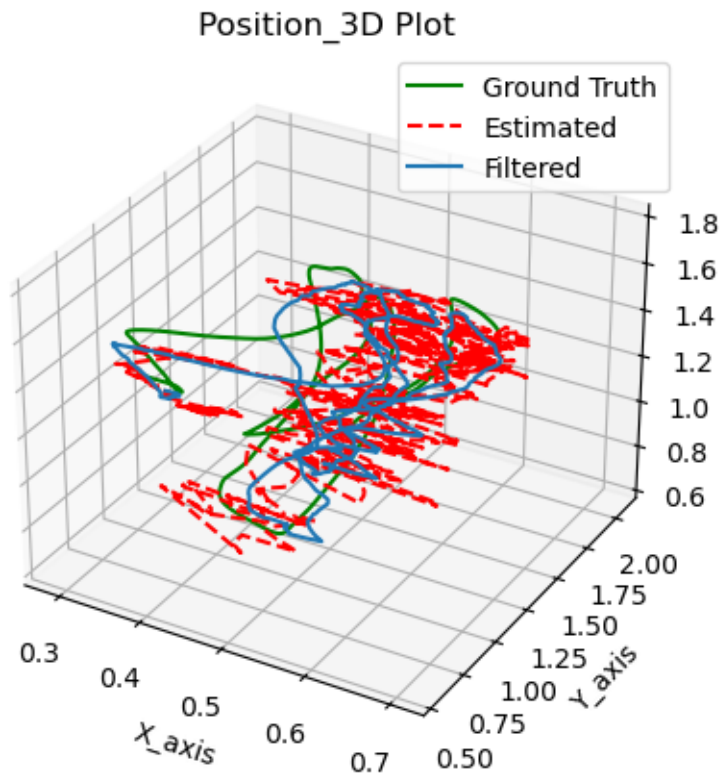


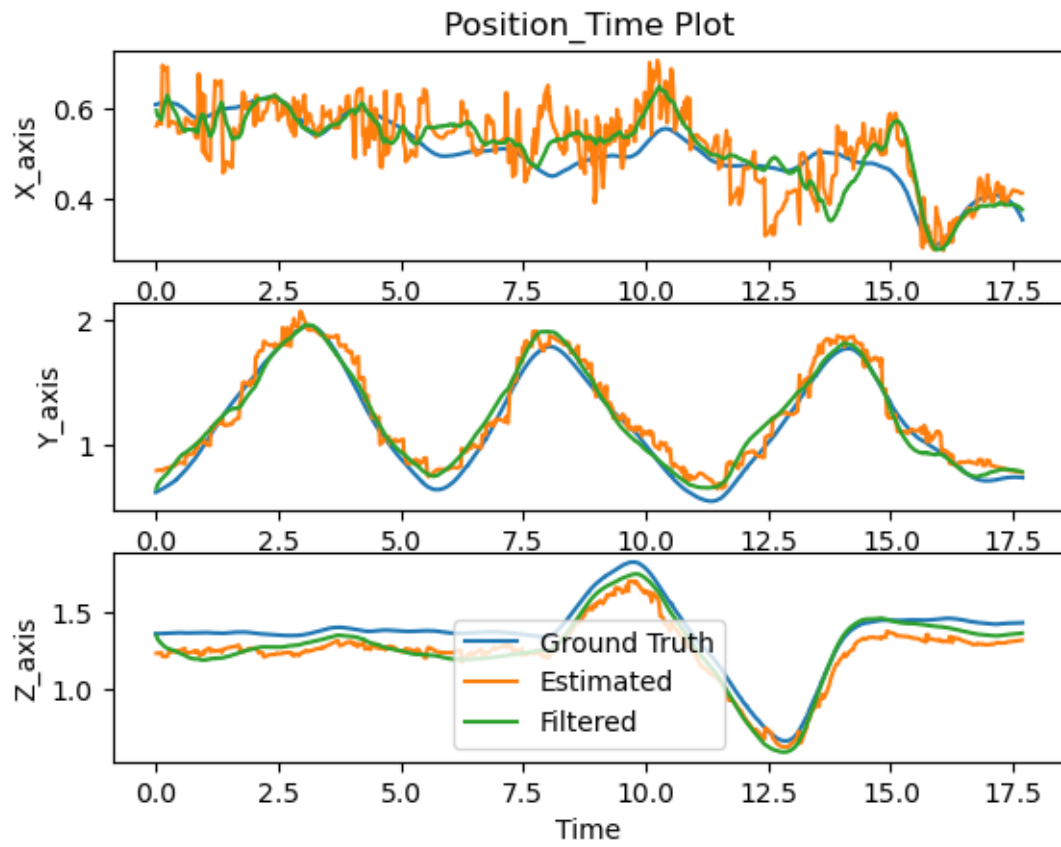


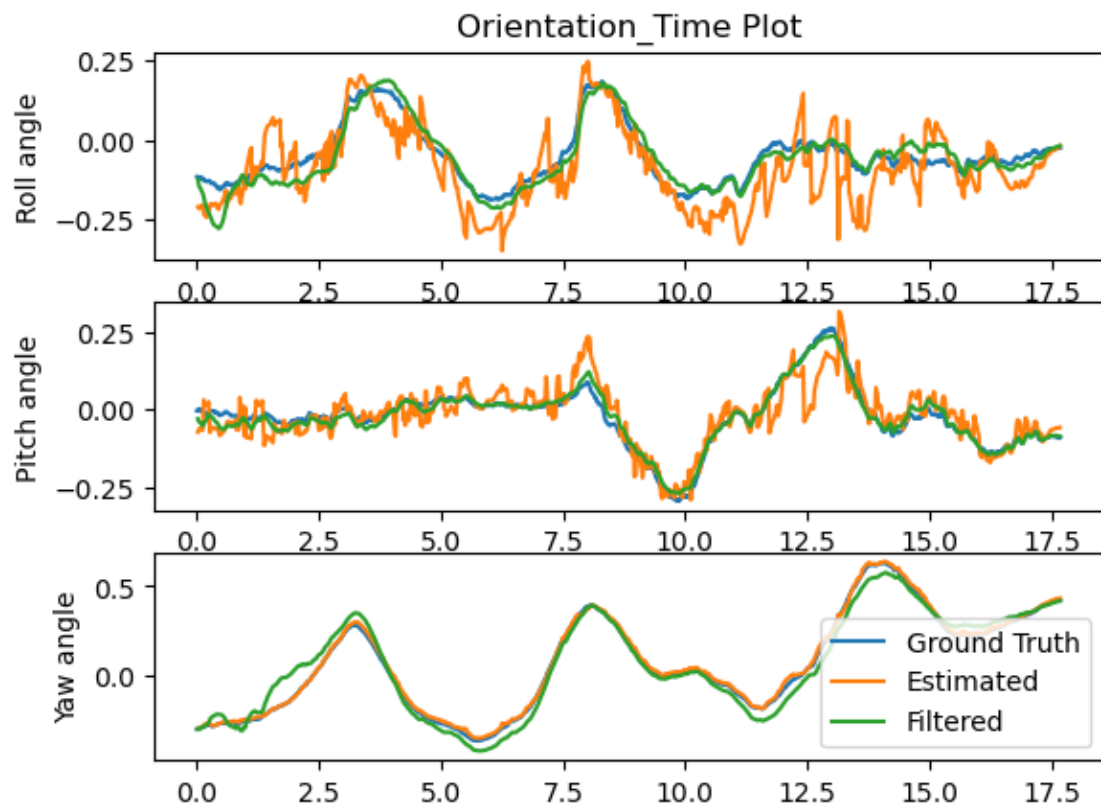




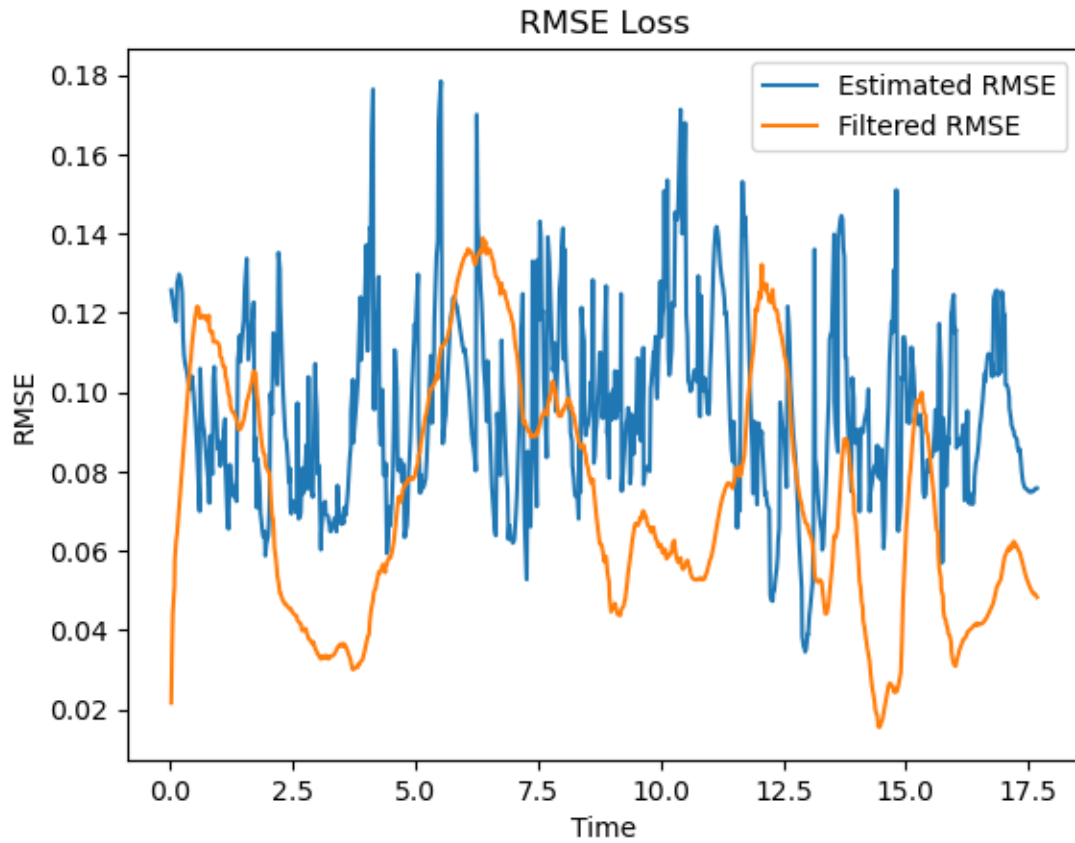
```
[ ]: #Simulate the results and plot  
  
from simulation_KF import simulate  
  
filename = "data\data\studentdata1.mat"  
simulate(filename)
```









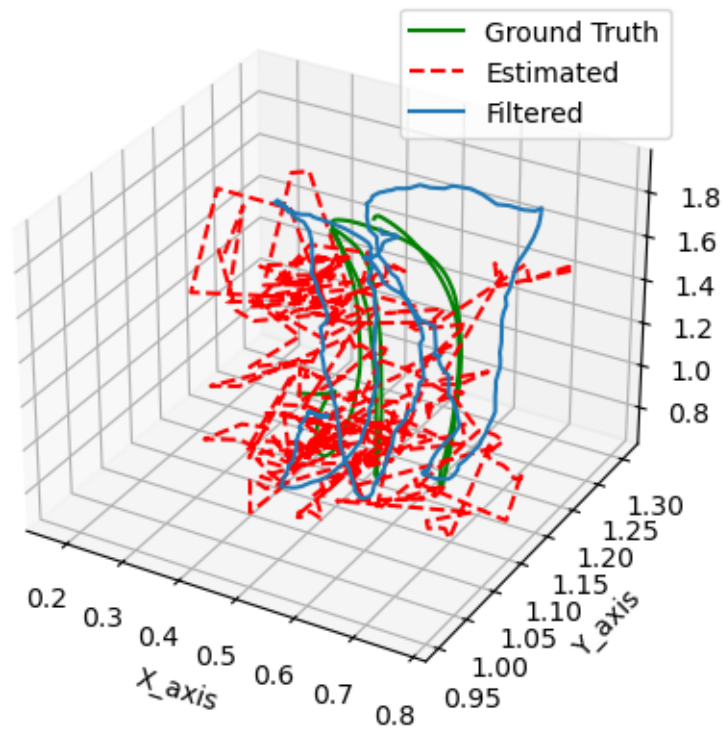


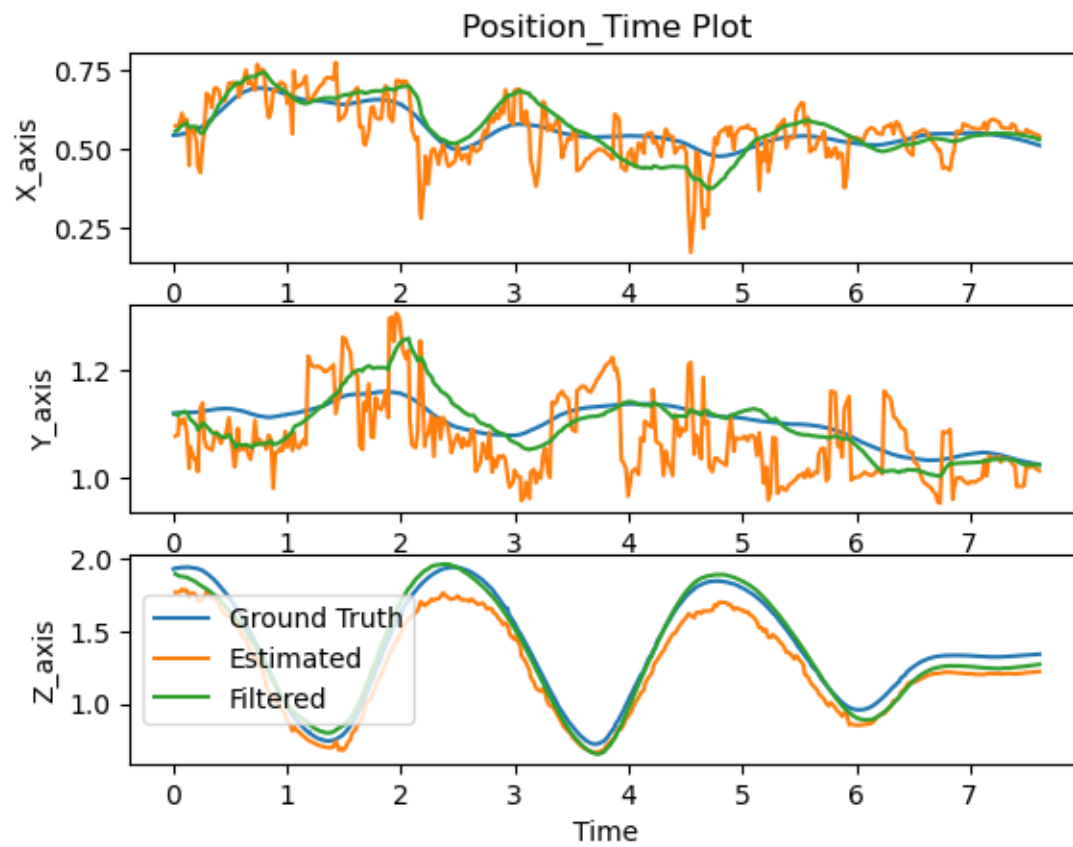
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[ ]: #Simulate the results and plot

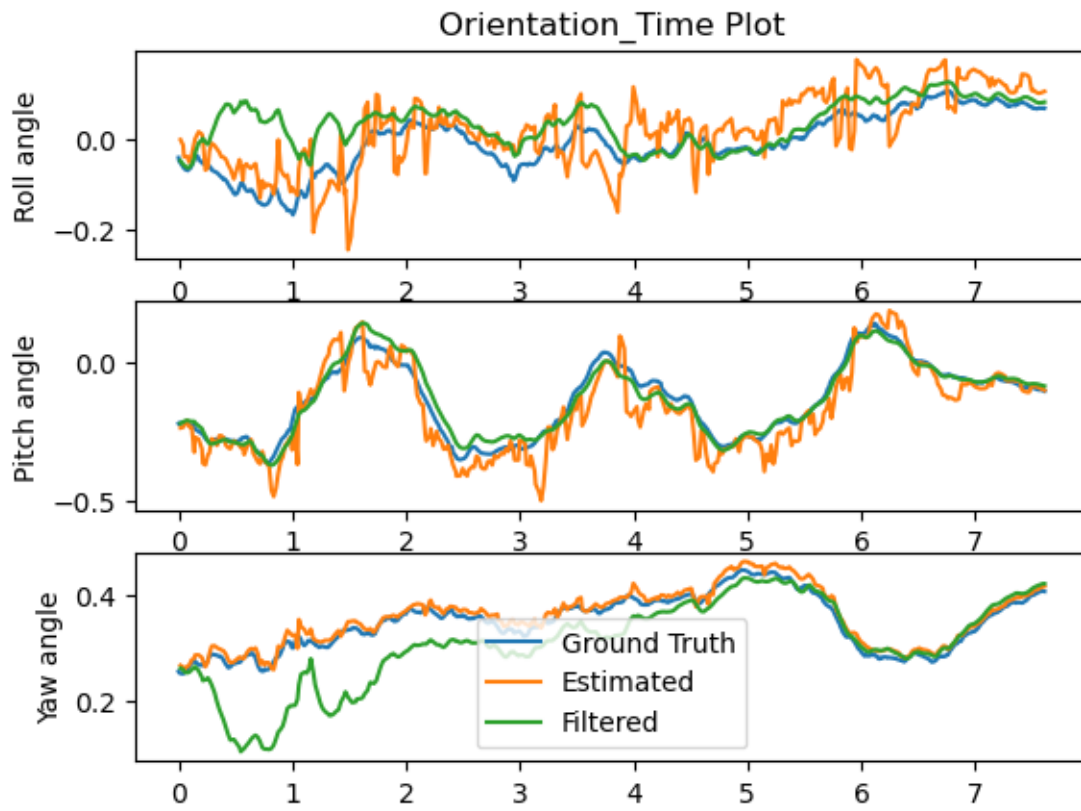
from simulation_KF import simulate

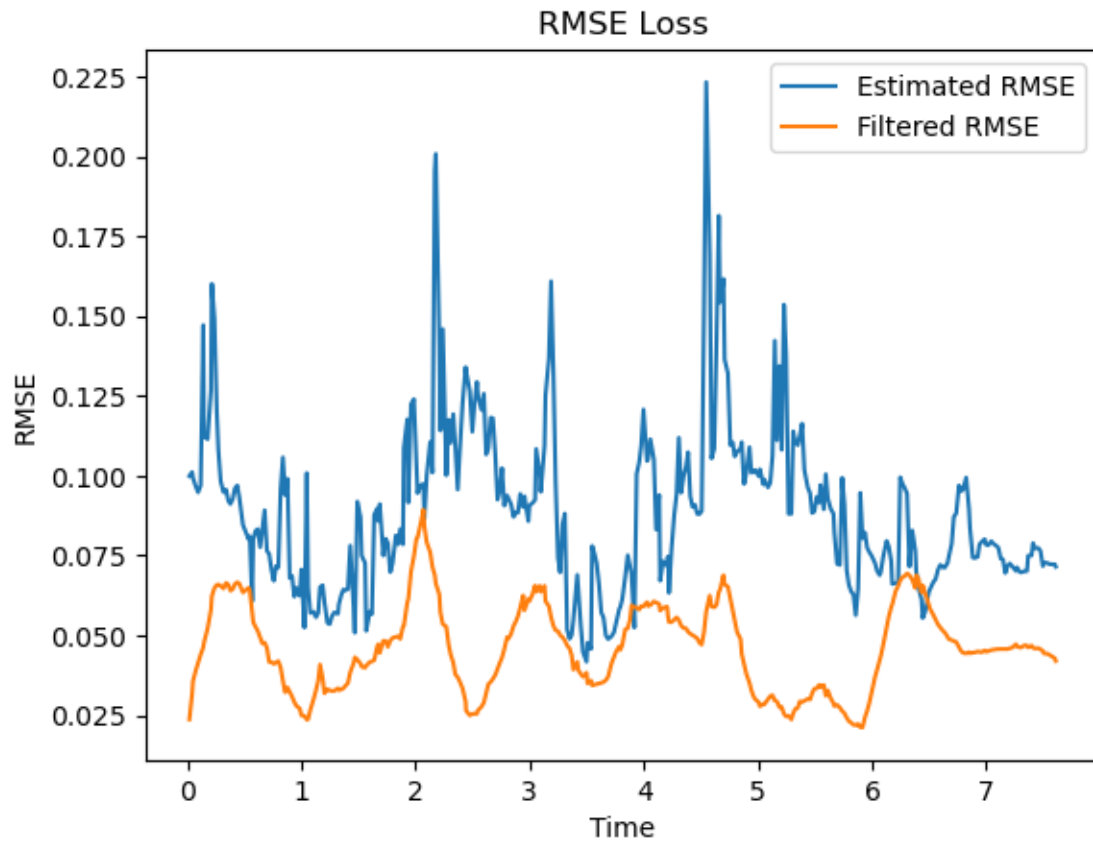
filename = "data\data\studentdata2.mat"
simulate(filename)
```

Position\_3D Plot







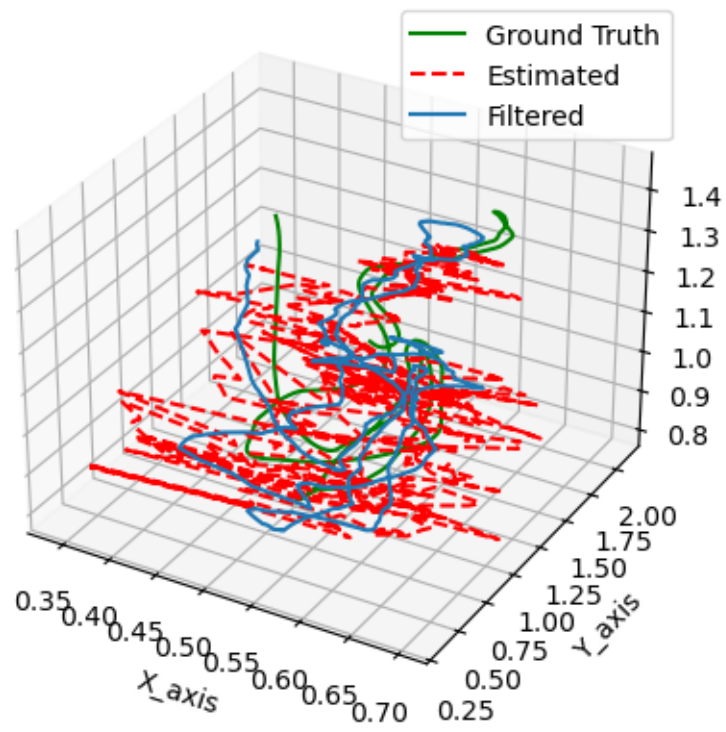


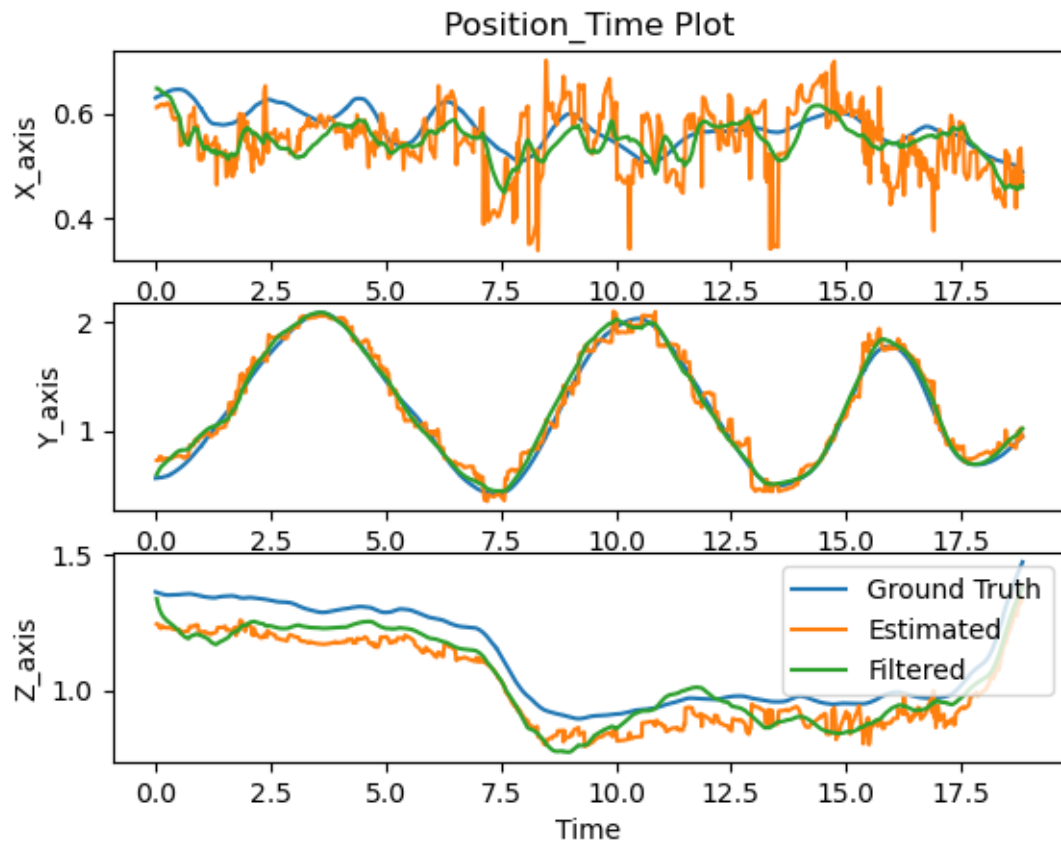
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[ ]: #Simulate the results and plot

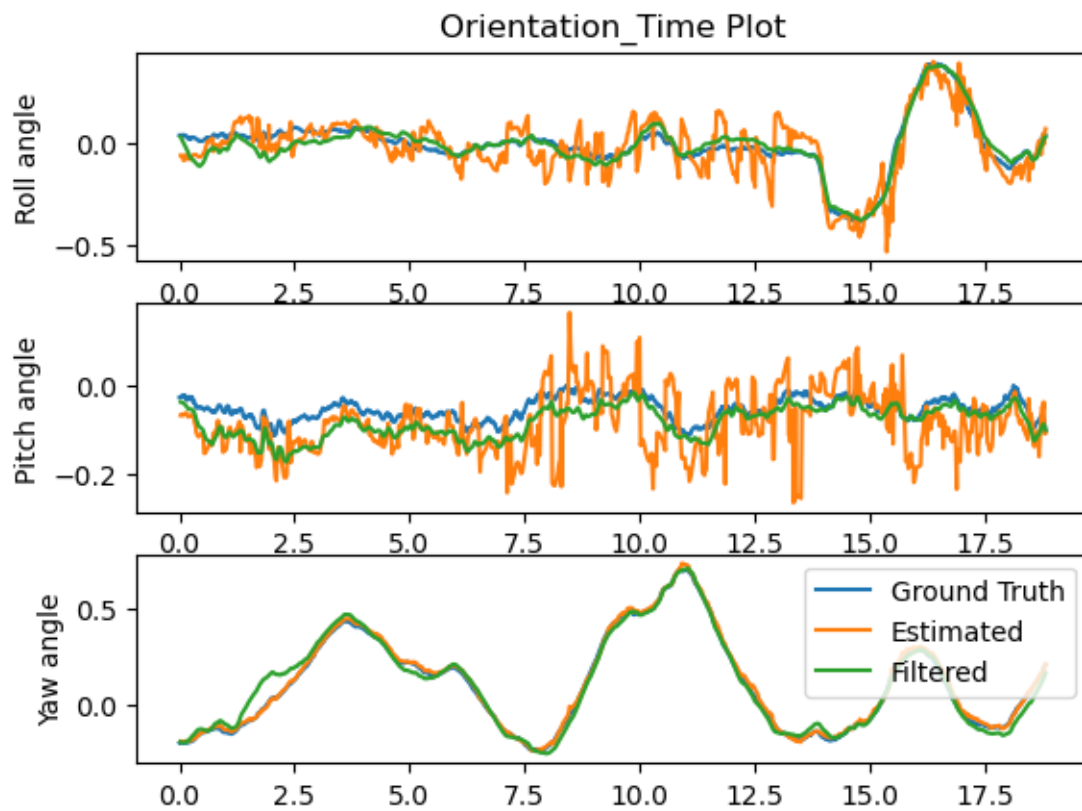
from simulation_KF import simulate

filename = "data\data\studentdata3.mat"
simulate(filename)
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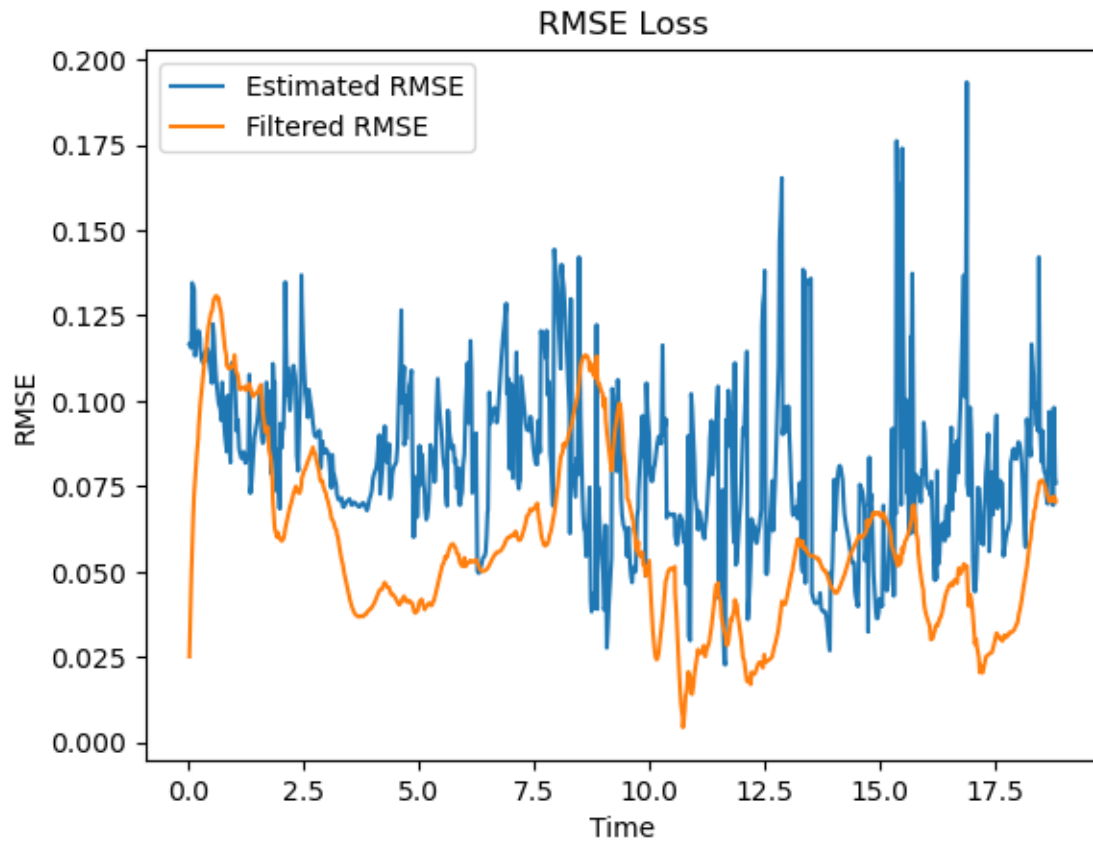
Position\_3D Plot







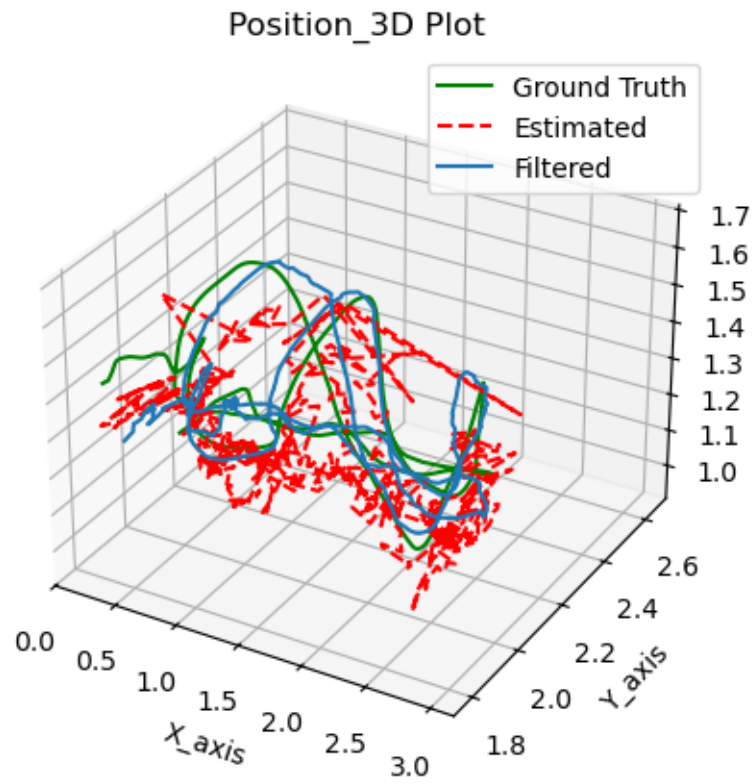


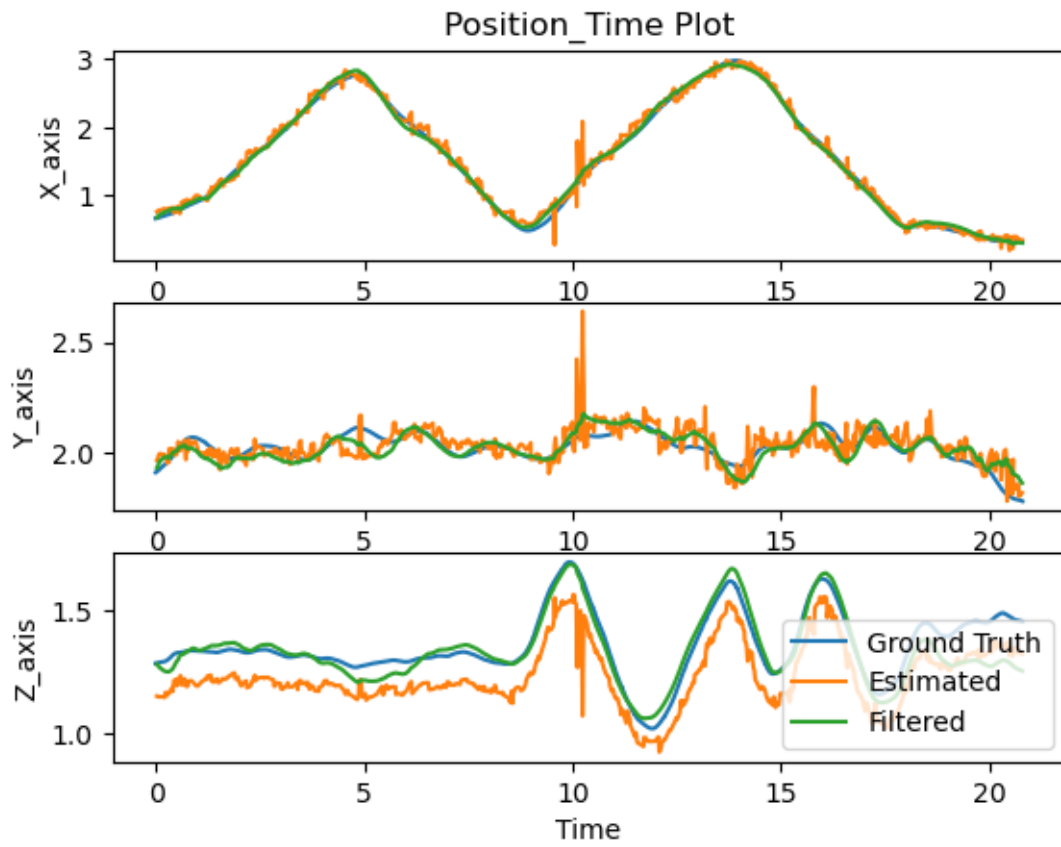


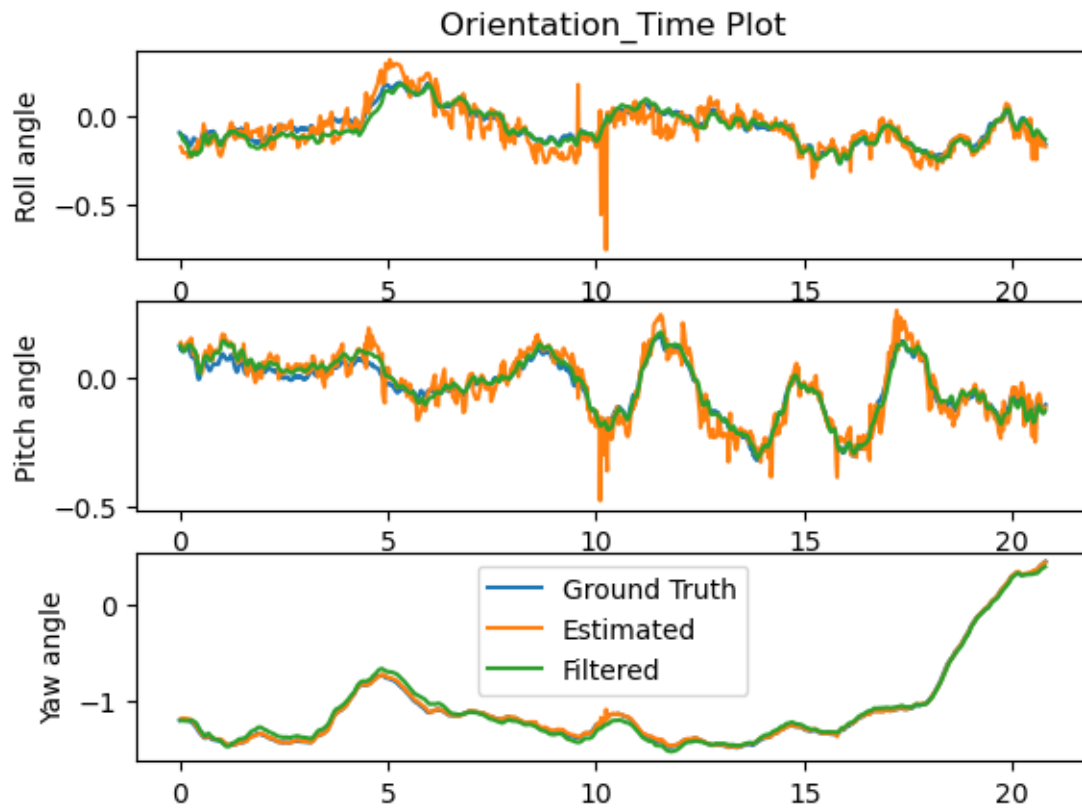
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[ ]: #Simulate the results and plot

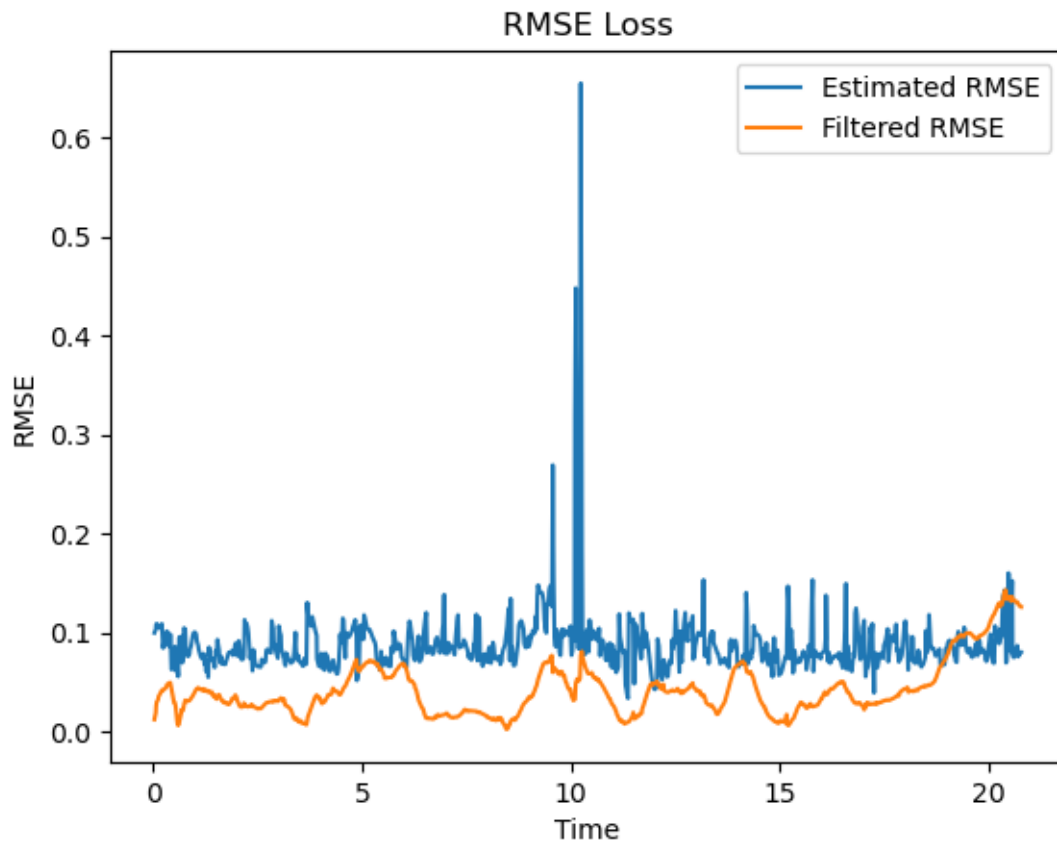
from simulation_KF import simulate

filename = "data\data\studentdata4.mat"
simulate(filename)
```





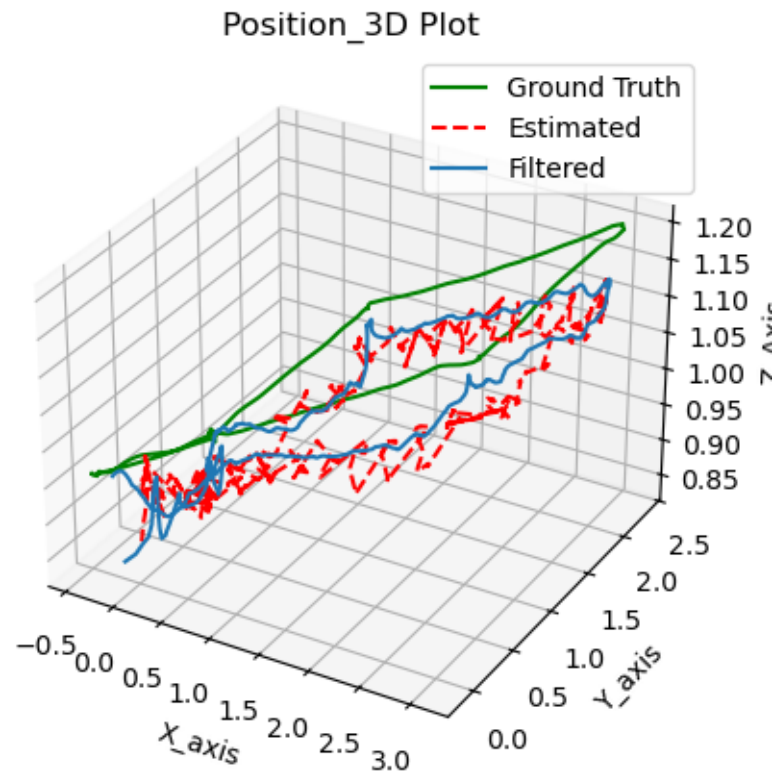


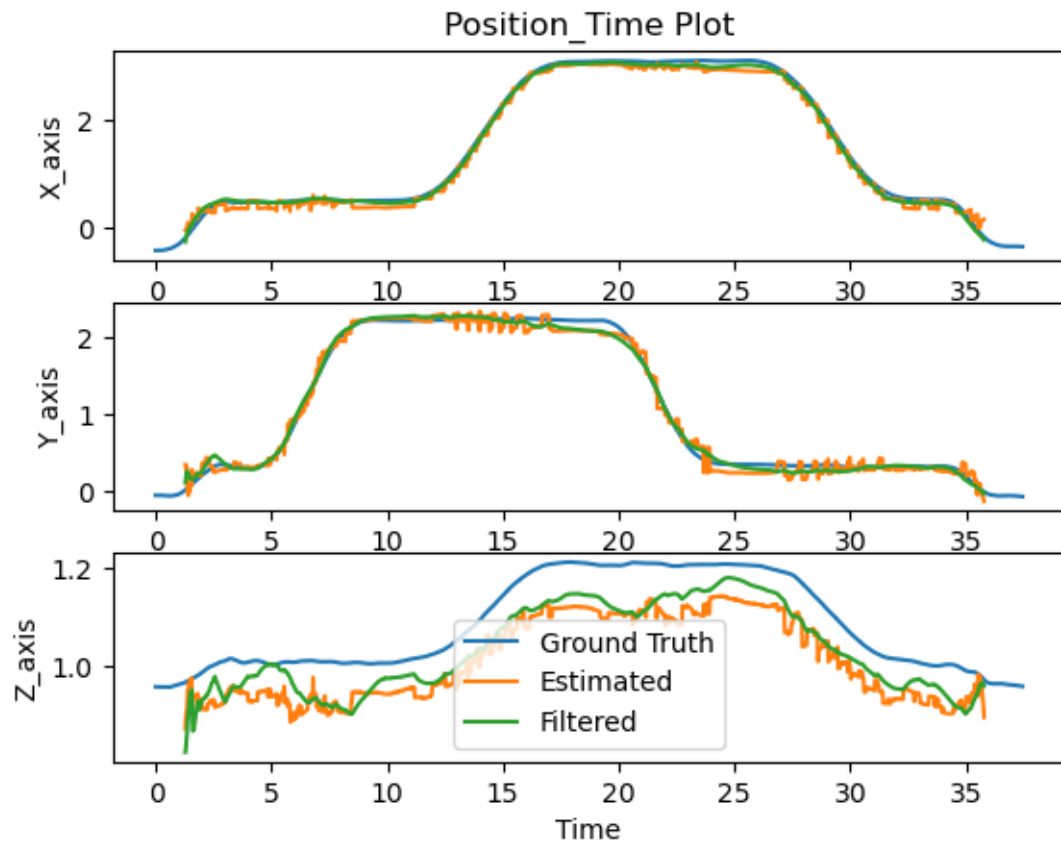


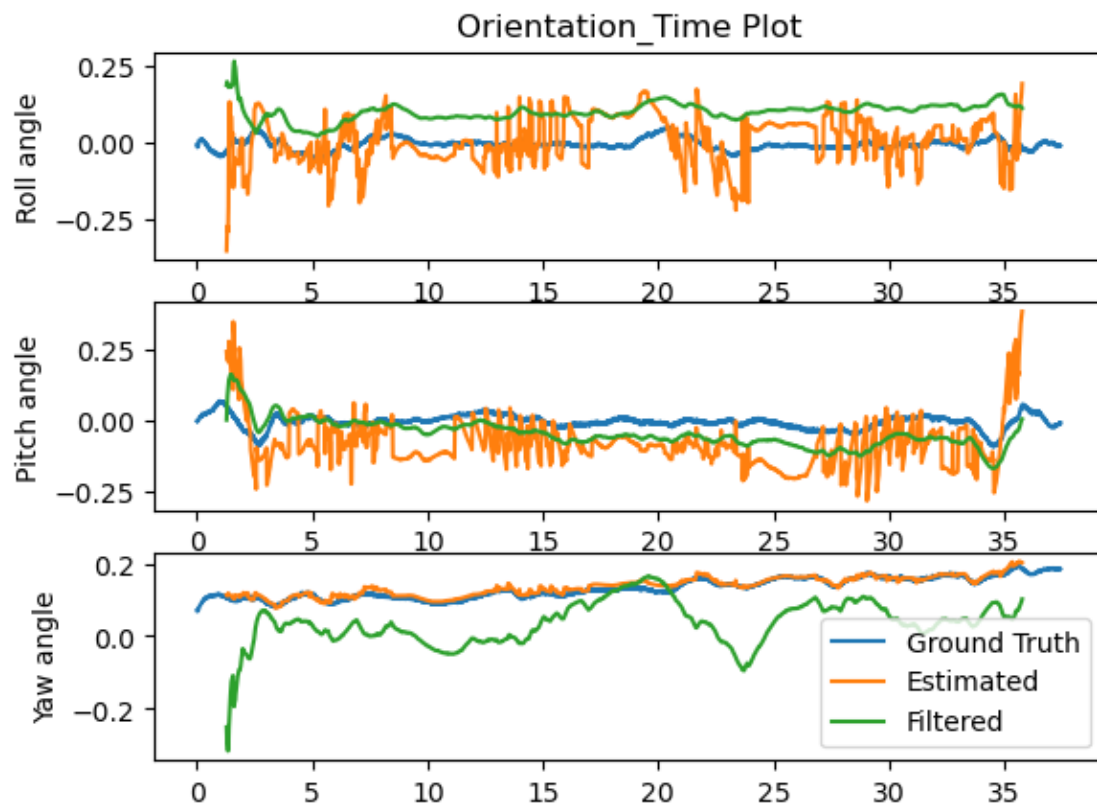
```
[ ]: #Simulate the results and plot

from simulation_KF import simulate

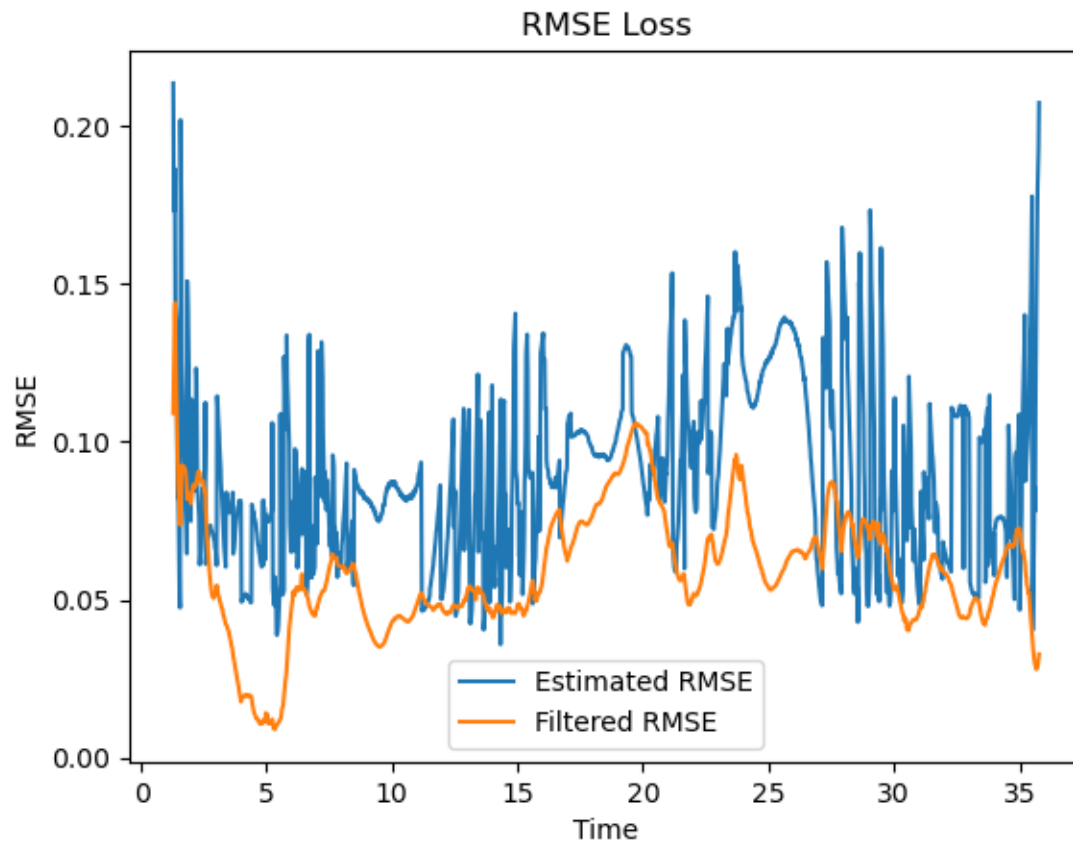
filename = "data\data\studentdata5.mat"
simulate(filename)
```







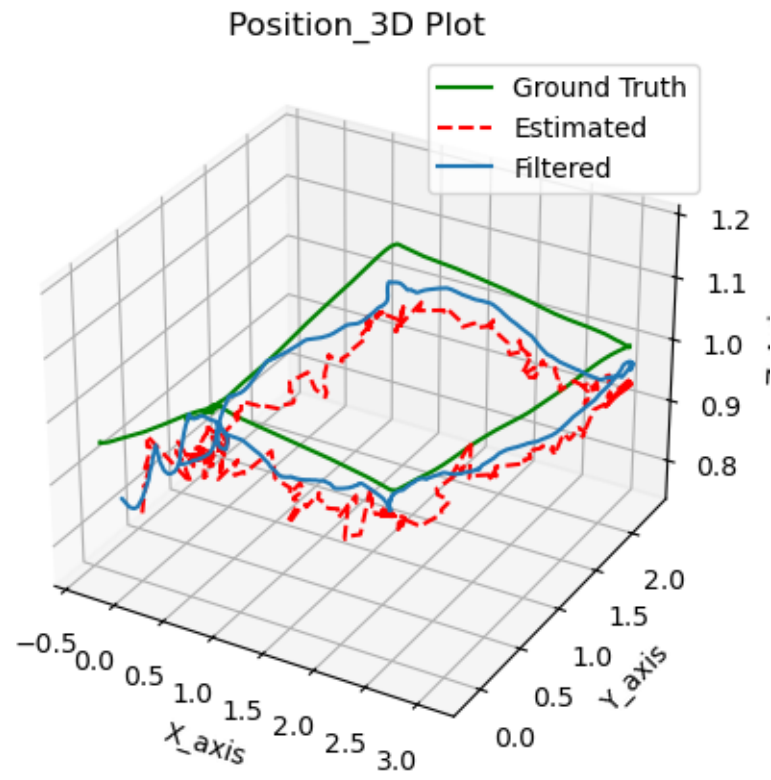


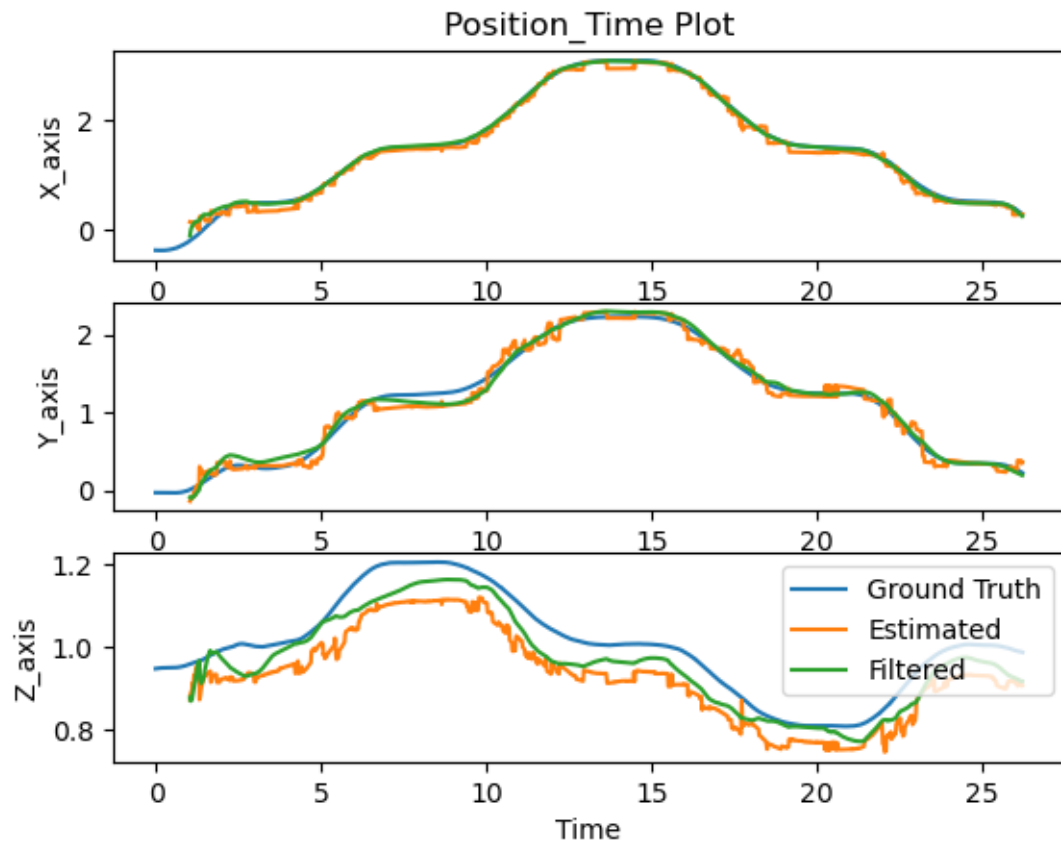


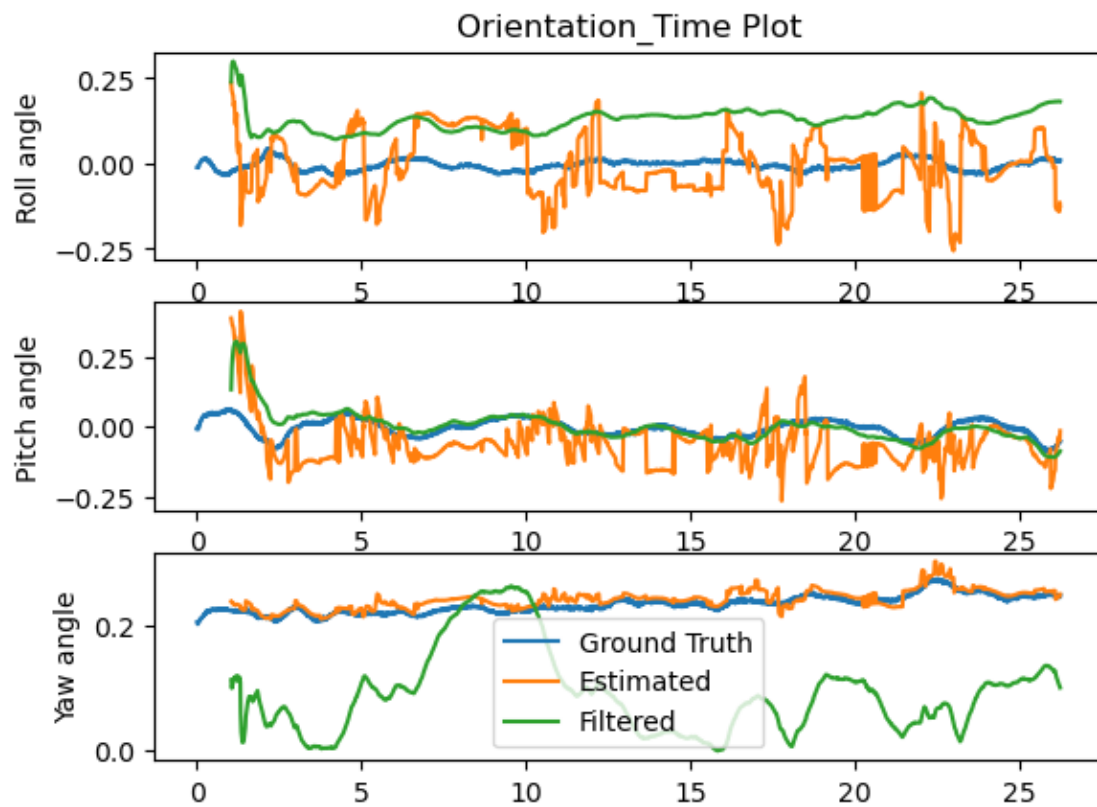
```
[ ]: #Simulate the results and plot

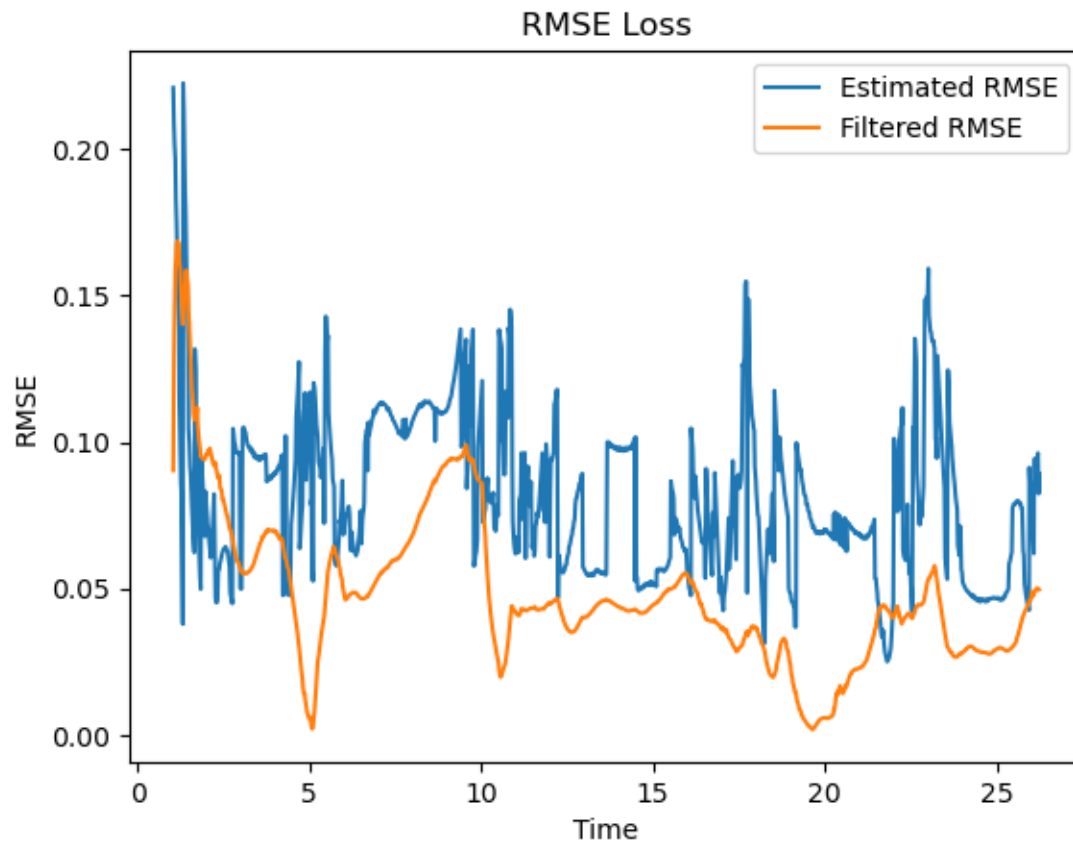
from simulation_KF import simulate

filename = "data\data\studentdata6.mat"
simulate(filename)
```









```
[ ]: #Simulate the results and plot

from simulation_KF import simulate

filename = "data\data\studentdata7.mat"
simulate(filename)
```

