

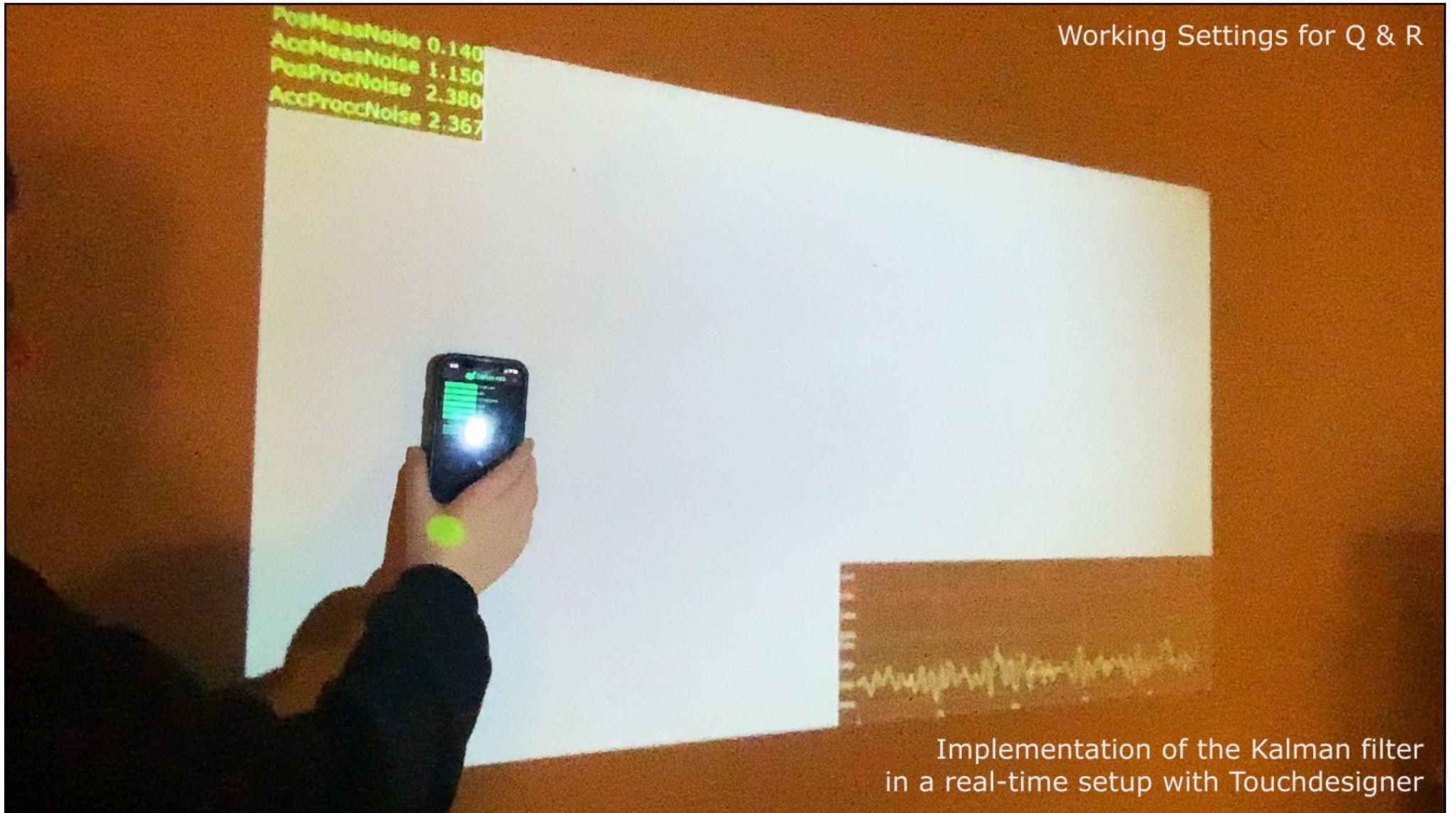
Physical Computing

Presentation „Hauptprojekt“
Tobias Wursthorn 1629762
2023 – 02 – 20



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PosMeasNoise 0.190
AccMeasNoise 0.544
PosProcNoise 1.862
AccProccNoise 1.862

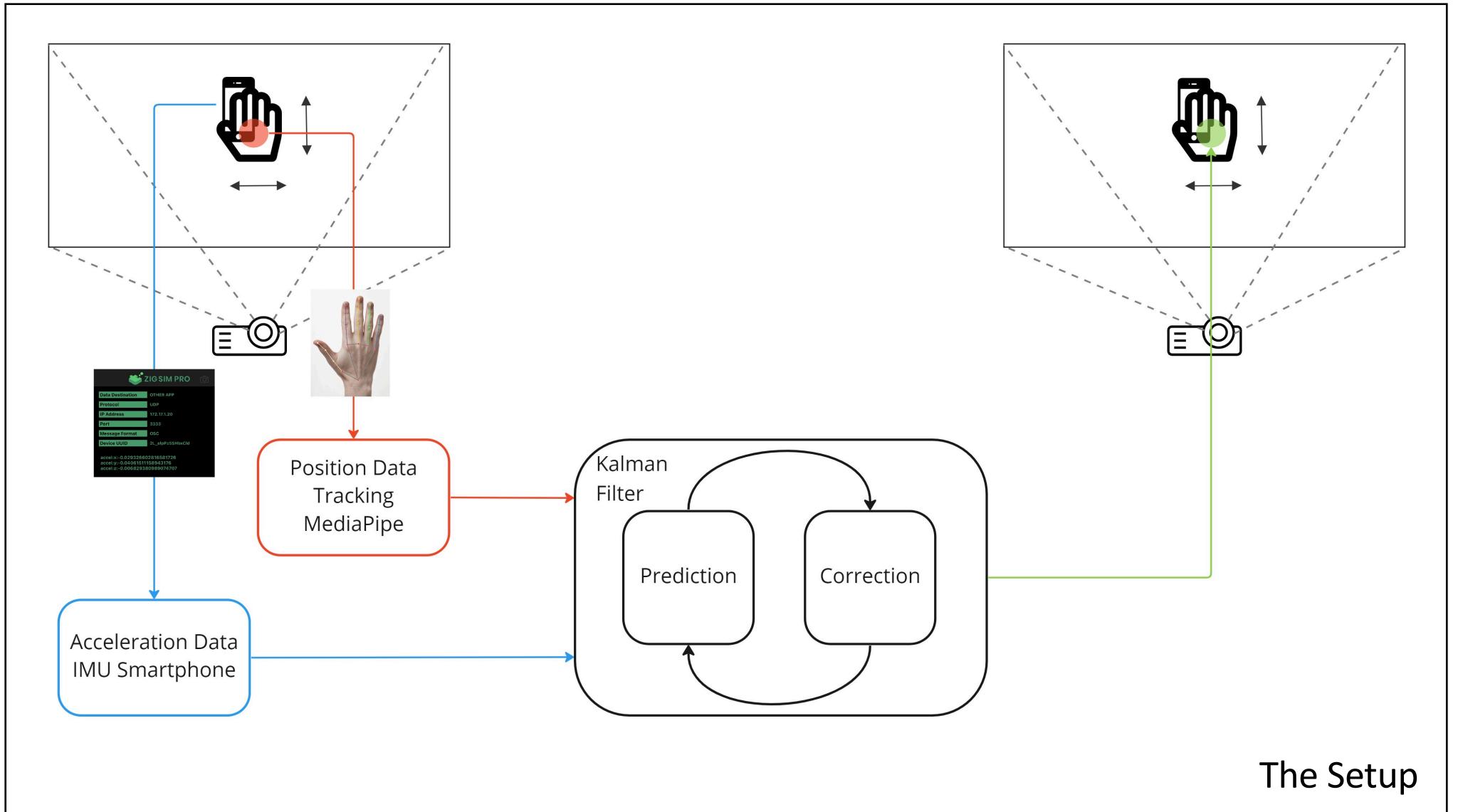
Implementation of the Kalman filter
in a real-time setup with Touchdesigner

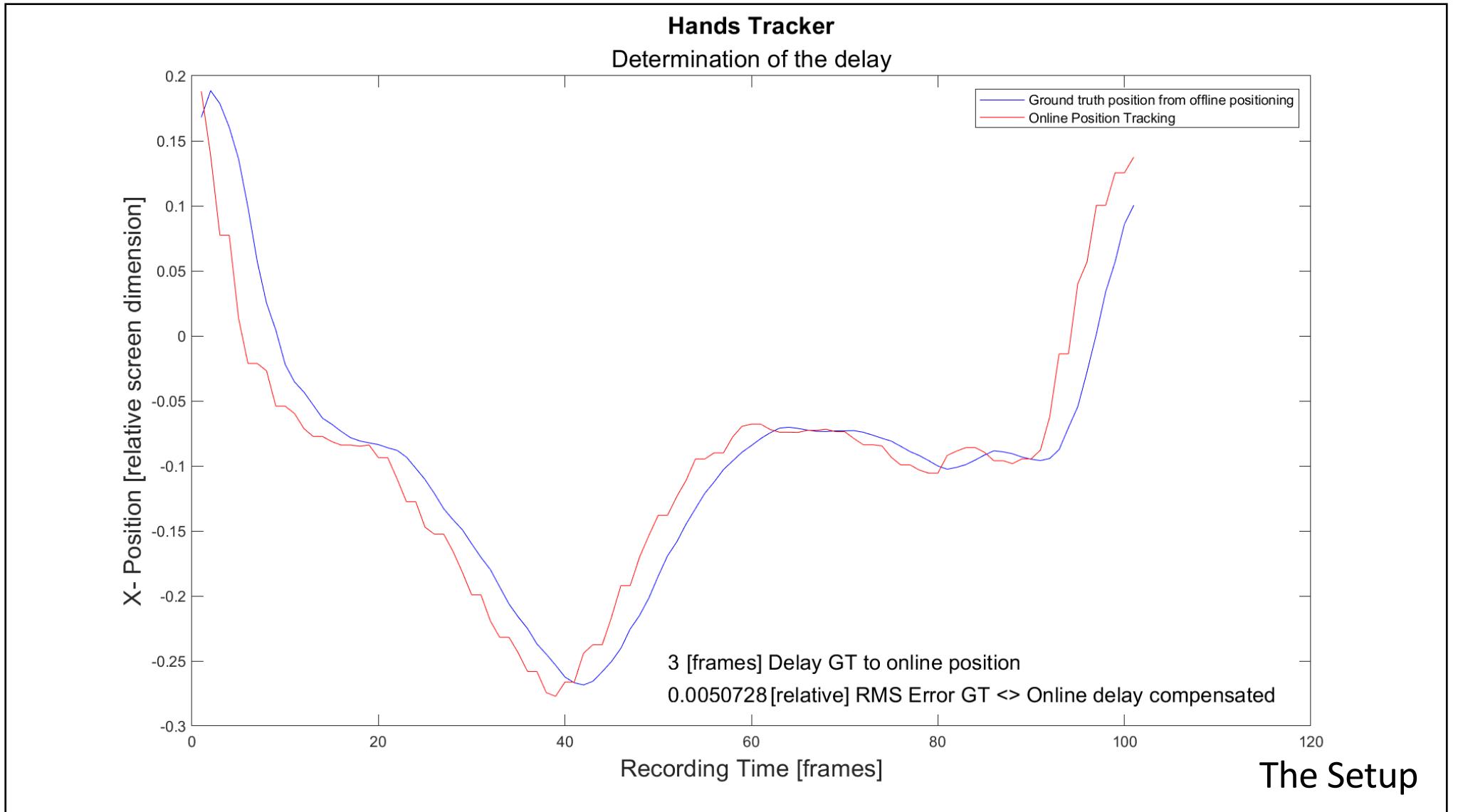


Research question

Is it possible to improve the tracking by combining acceleration data from the IMU of a cell phone and the position data of a hand of a camera-based tracking in such a way that the latency of the camera tracking is compensated and the temporary loss of measurement data can be compensated?

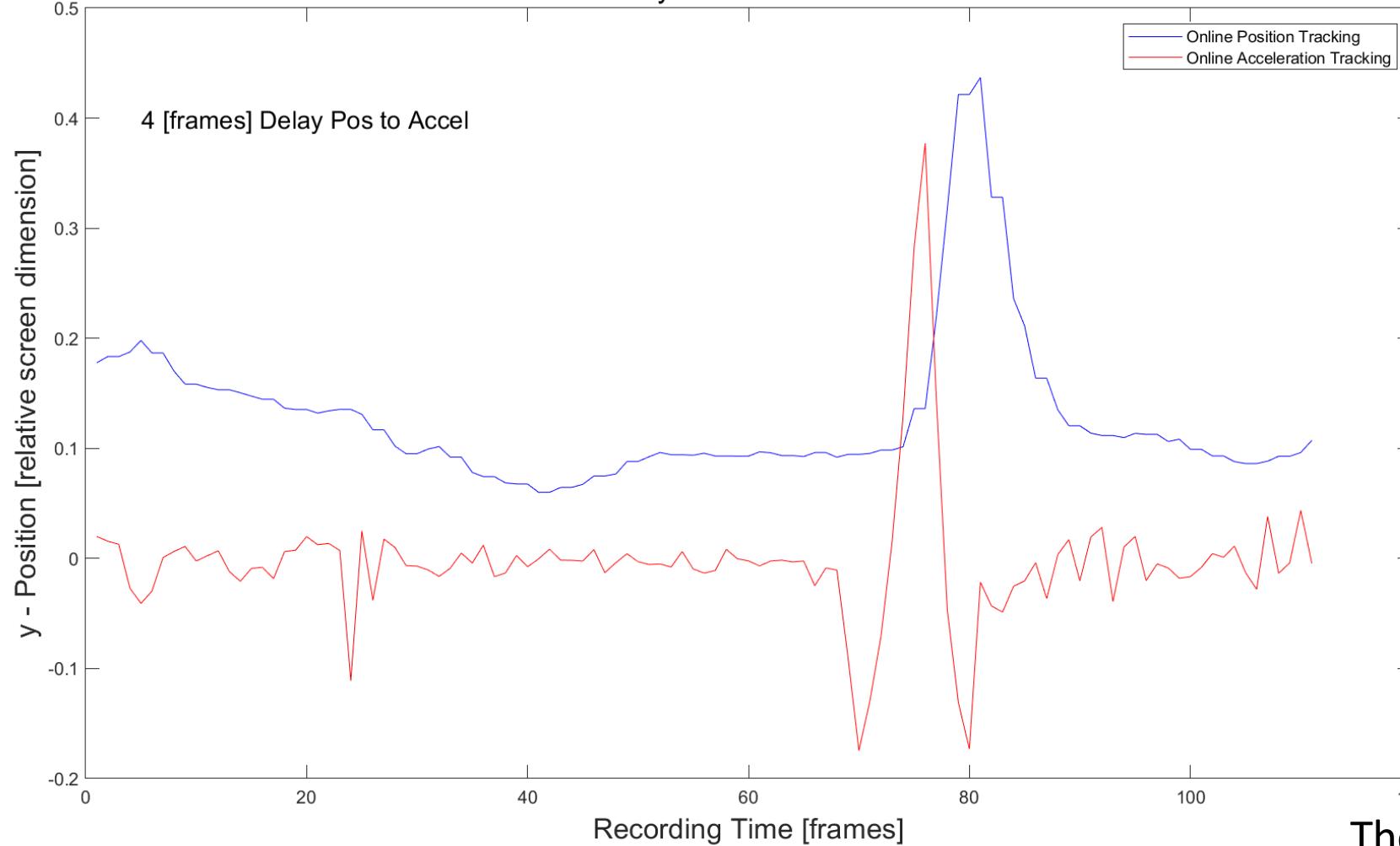






Hands Tracker

Determination of the delay Online Position to Online Acceleration



The Setup

Kalman Filter with Constant Acceleration Model

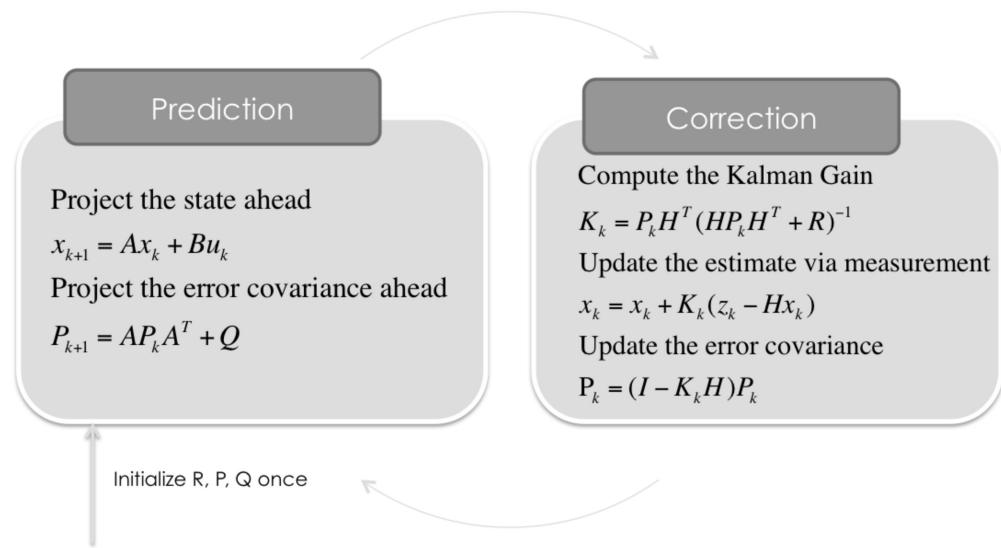
$$x_{k+1} = A \cdot x_k + B \cdot u$$

$$y = H \cdot x$$

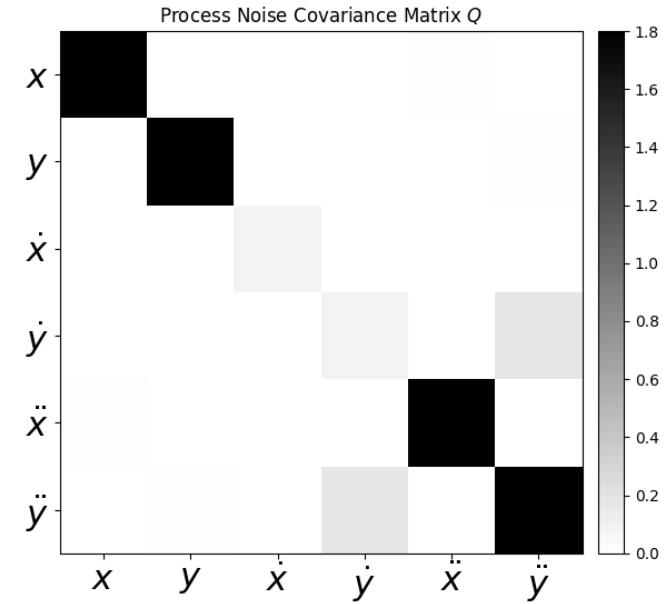
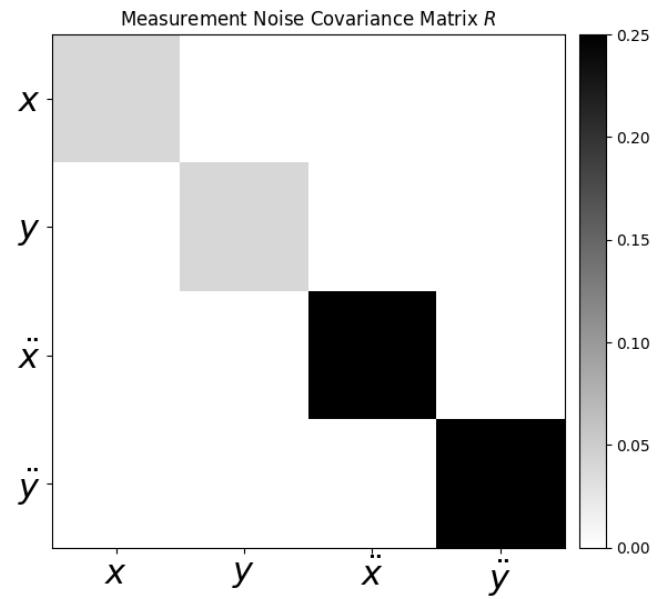
$$x_{k+1} = \begin{bmatrix} 1 & 0 & \Delta t & 0 & \frac{1}{2}\Delta t^2 & 0 \\ 0 & 1 & 0 & \Delta t & 0 & \frac{1}{2}\Delta t^2 \\ 0 & 0 & 1 & 0 & \Delta t & 0 \\ 0 & 0 & 0 & 1 & 0 & \Delta t \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} x \\ y \\ \dot{x} \\ \dot{y} \\ \ddot{x} \\ \ddot{y} \end{bmatrix}_k$$
$$y = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \cdot x$$

Kalman Filter with Constant Acceleration Model

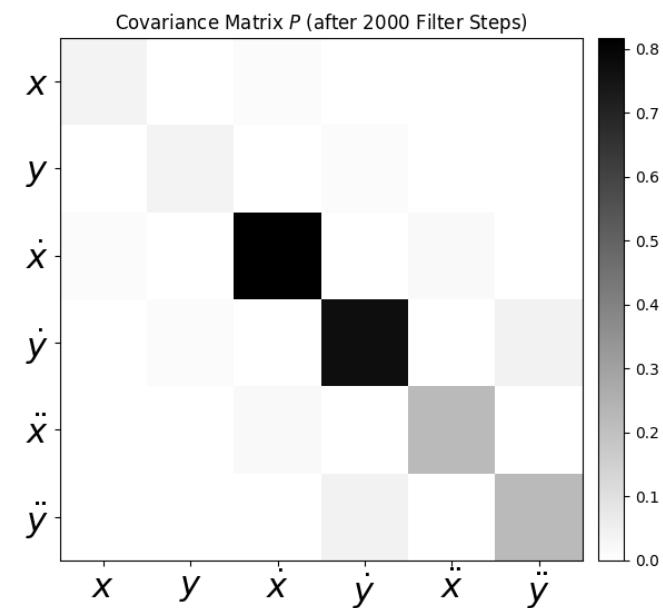
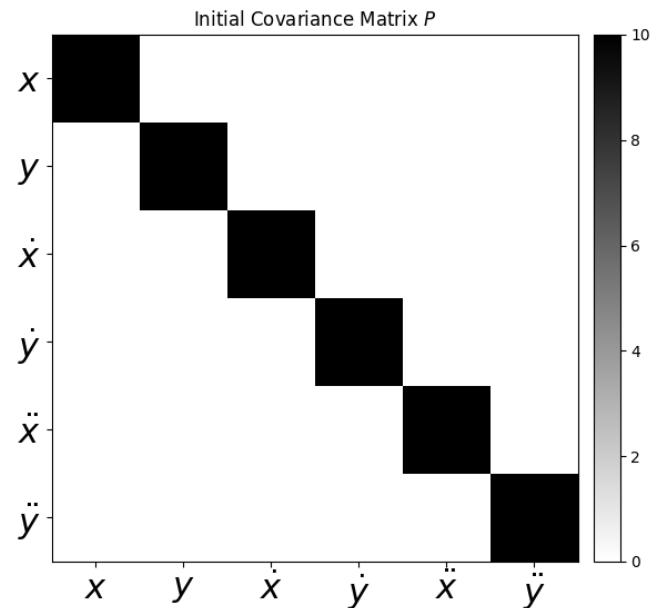
$$Q = \begin{bmatrix} \sigma_x^2 & 0 & \sigma_{x\dot{x}} & 0 & \sigma_{x\ddot{x}} & 0 \\ 0 & \sigma_y^2 & 0 & \sigma_{y\dot{y}} & 0 & \sigma_{y\ddot{y}} \\ \sigma_{\dot{x}x} & 0 & \sigma_{\dot{x}}^2 & 0 & \sigma_{\dot{x}\ddot{x}} & 0 \\ 0 & \sigma_{\dot{y}y} & 0 & \sigma_{\dot{y}}^2 & 0 & \sigma_{\dot{y}\ddot{y}} \\ \sigma_{\ddot{x}x} & 0 & \sigma_{\ddot{x}\dot{x}} & 0 & \sigma_{\ddot{x}}^2 & 0 \\ 0 & \sigma_{\ddot{y}y} & 0 & \sigma_{\ddot{y}\dot{y}} & 0 & \sigma_{\ddot{y}}^2 \end{bmatrix} \cdot \sigma_j$$



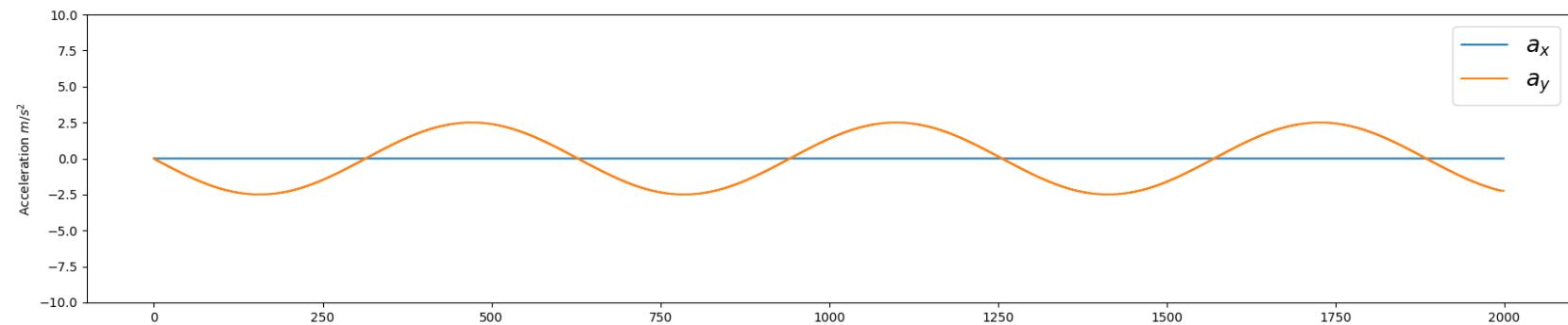
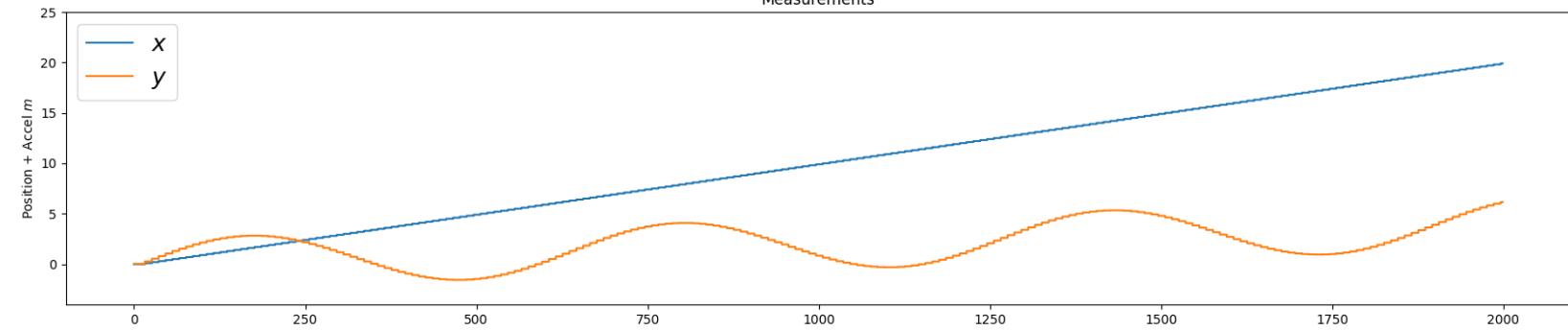
Kalman Filter with Constant Acceleration Model



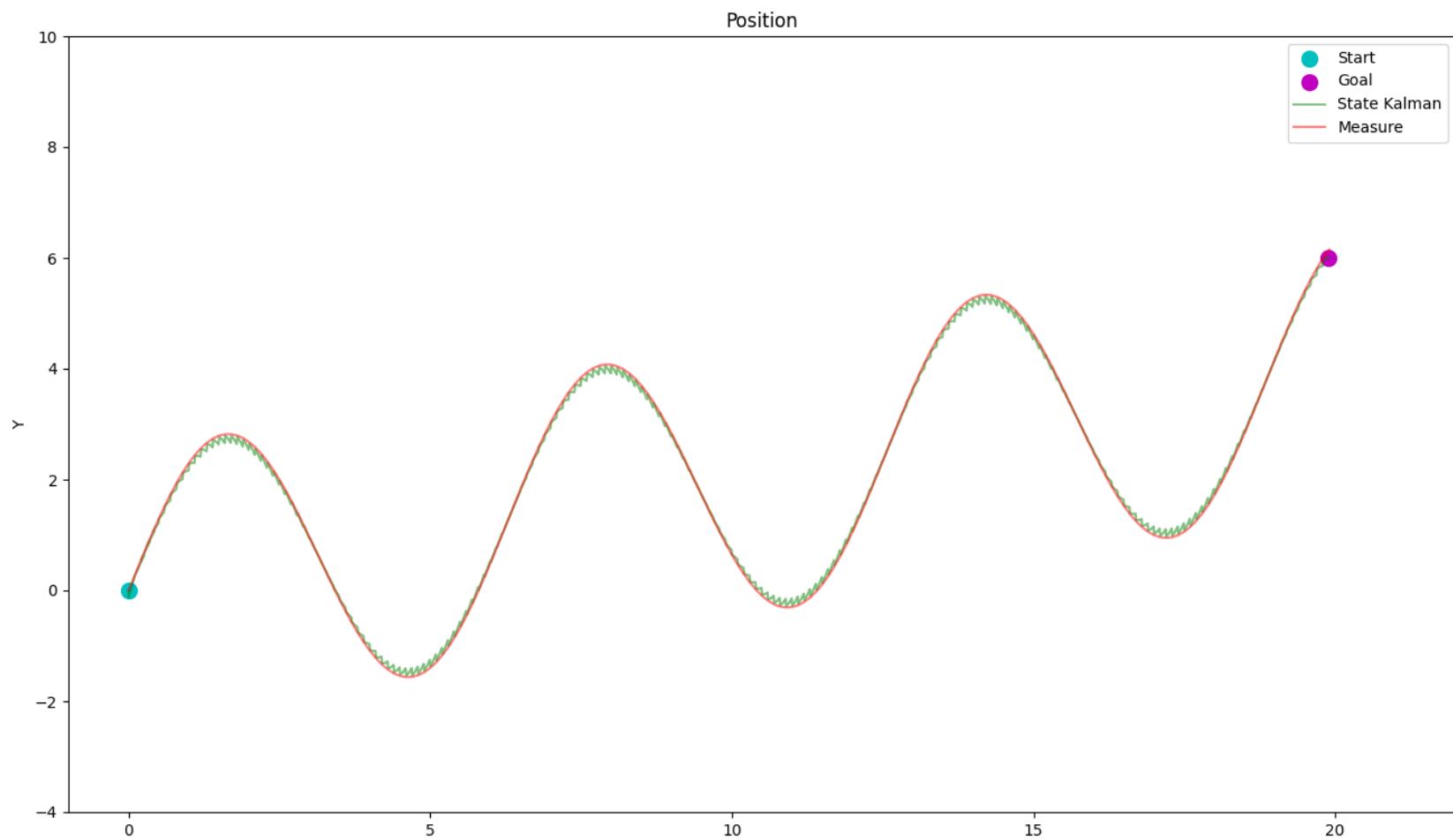
Kalman Filter with Constant Acceleration Model



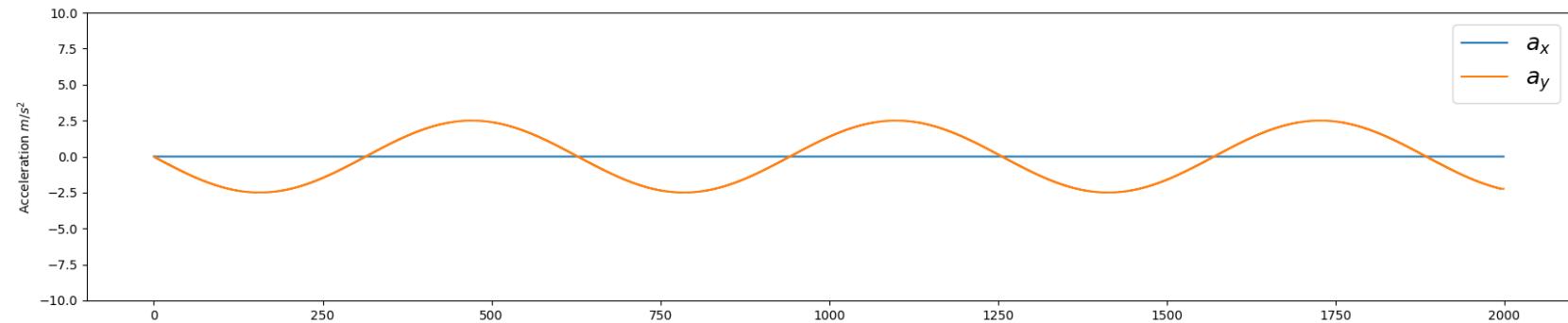
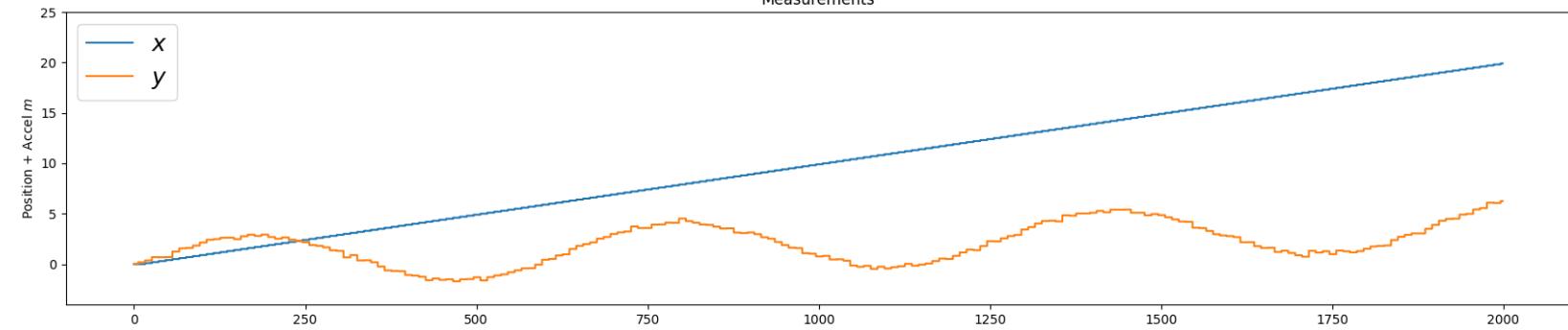
Measurements



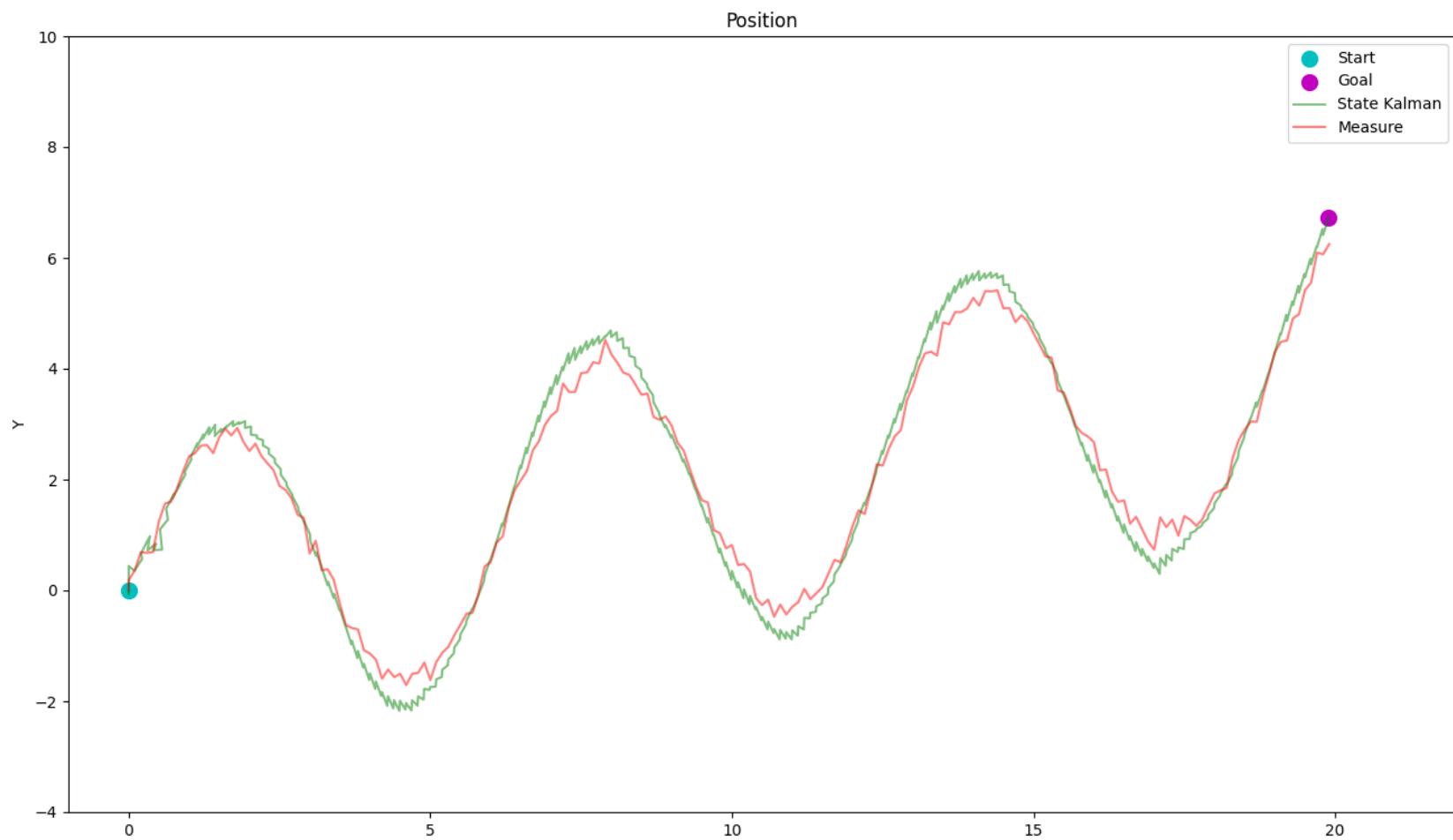
Simulation in PyCharm



Measurements

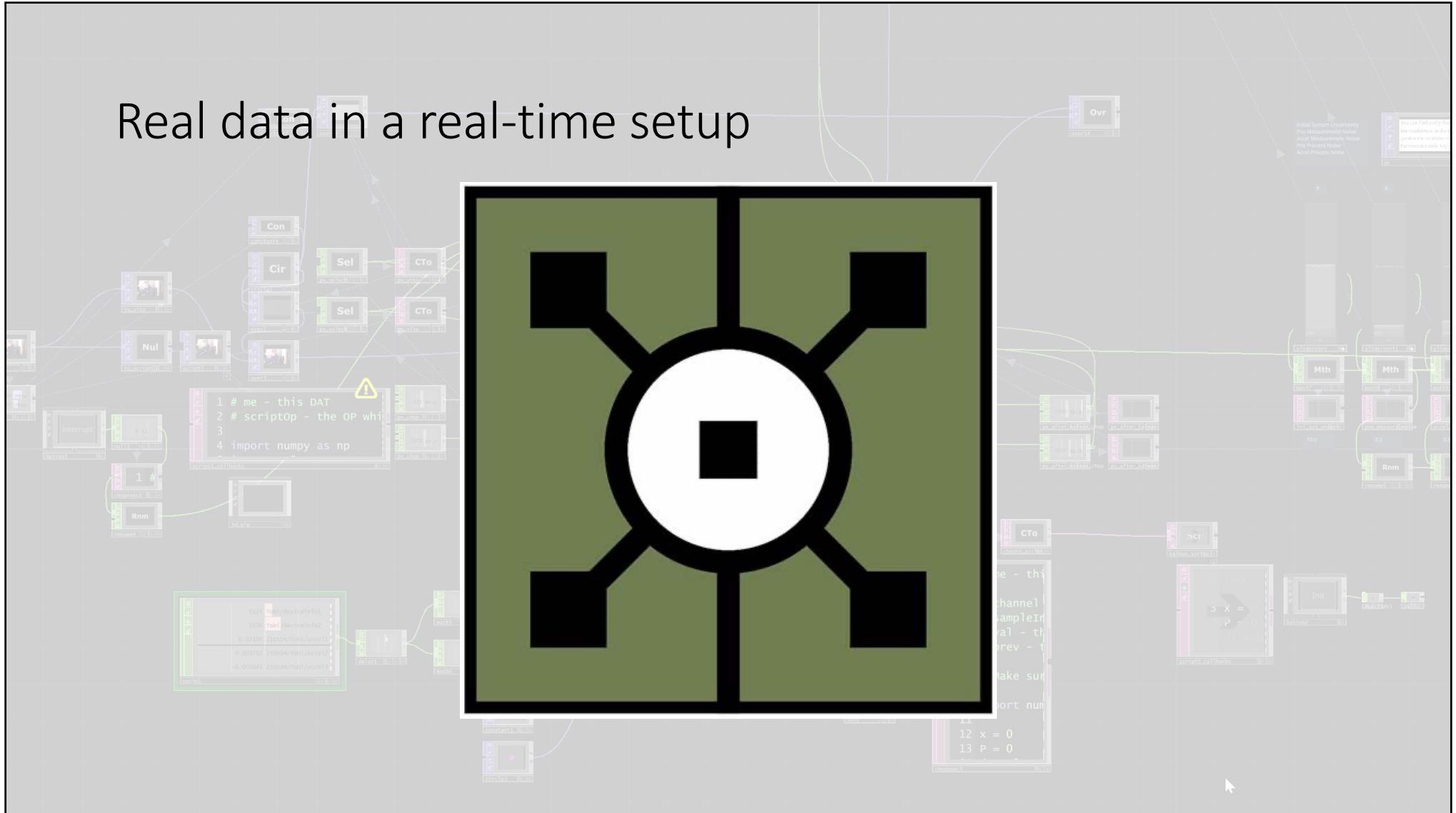


Simulation in PyCharm



Simulation in PyCharm

Real data in a real-time setup

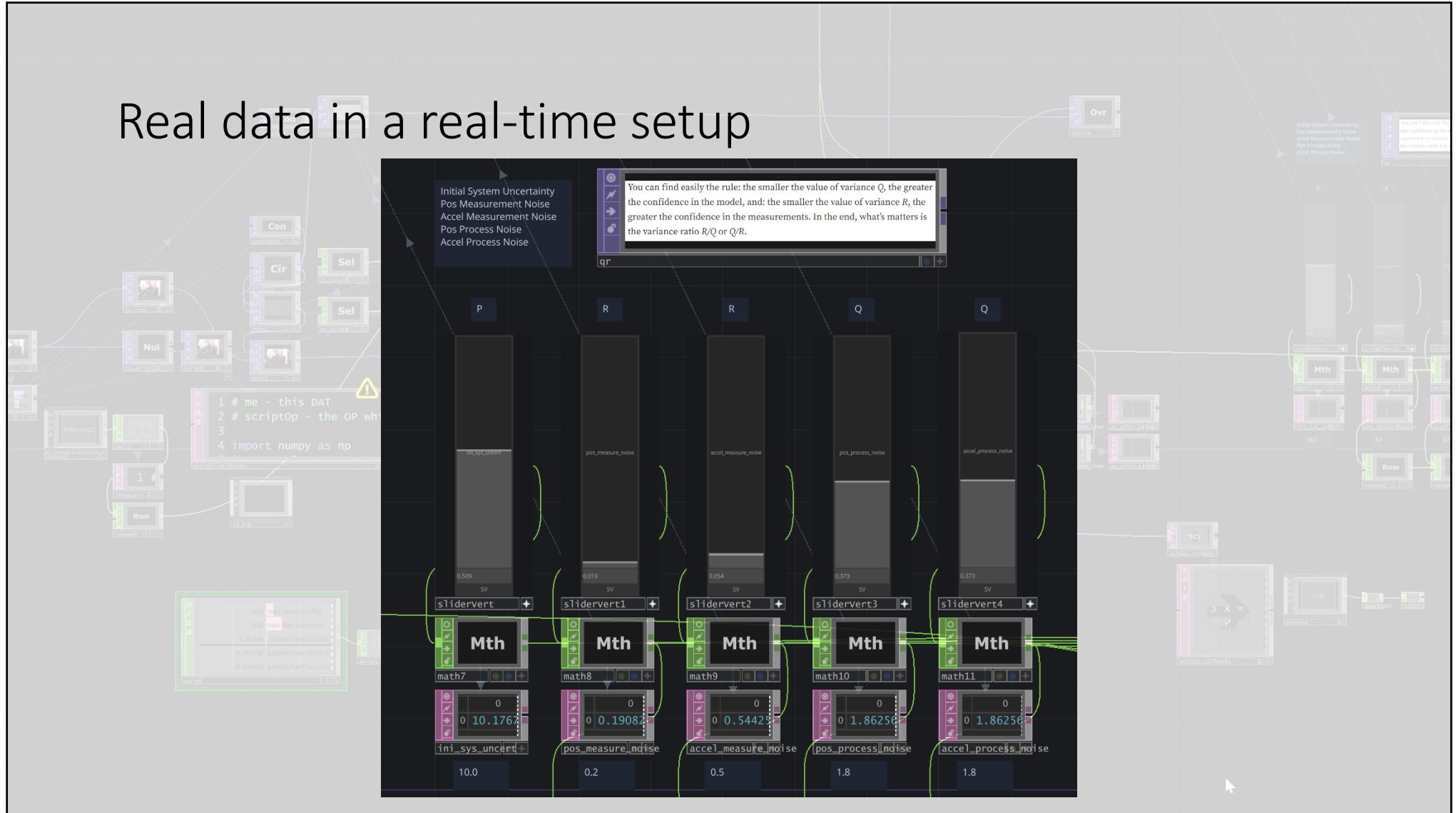


Real data in a real-time setup

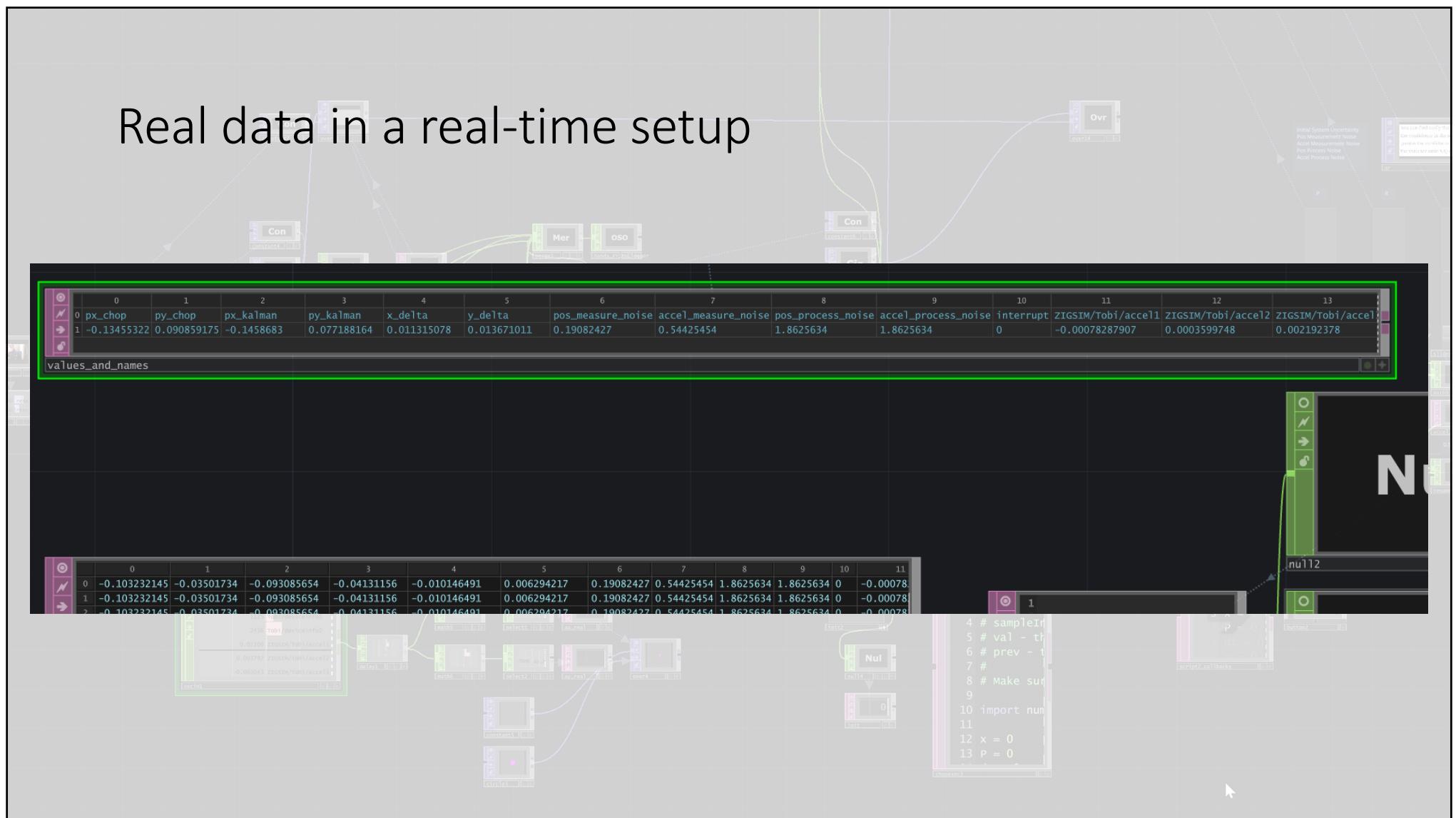
- Camera Tracking with MediaPipe inside Touchdesigner Python Environment
- ZigSim Pro to send the raw IMU Acceleration Data from cell phone to Touchdesigner
- Full Implementation of the Init and Update Process inside the Touchdesigner Python Environment
- Real-time adjustable parameter for Q and R
- Real-time error graph

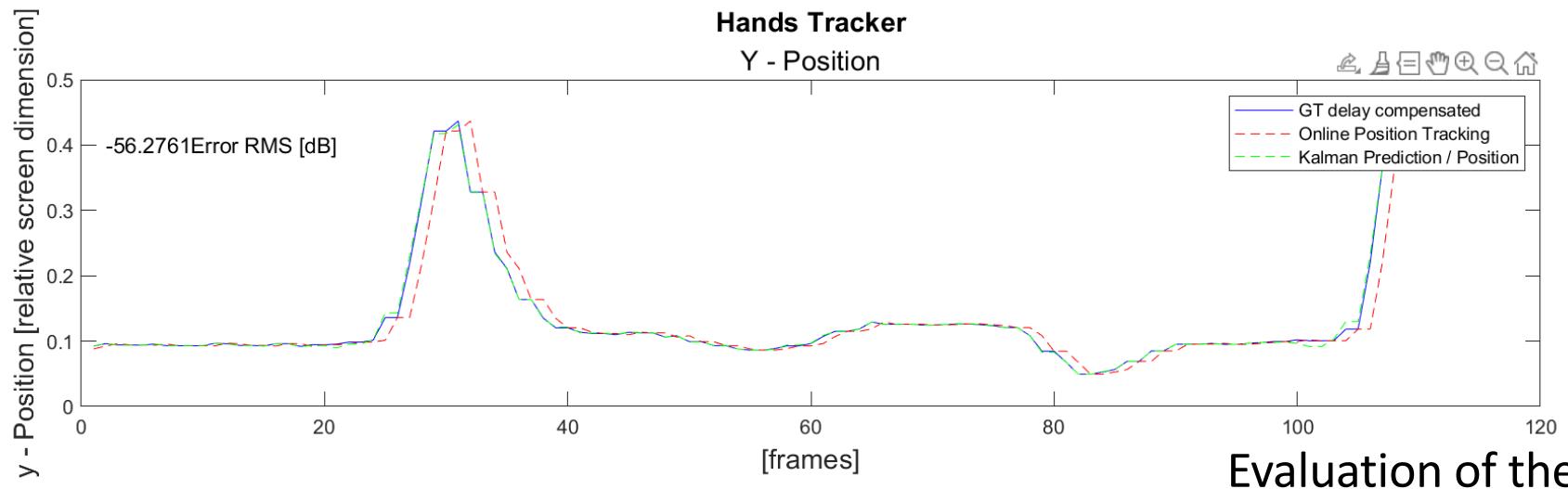
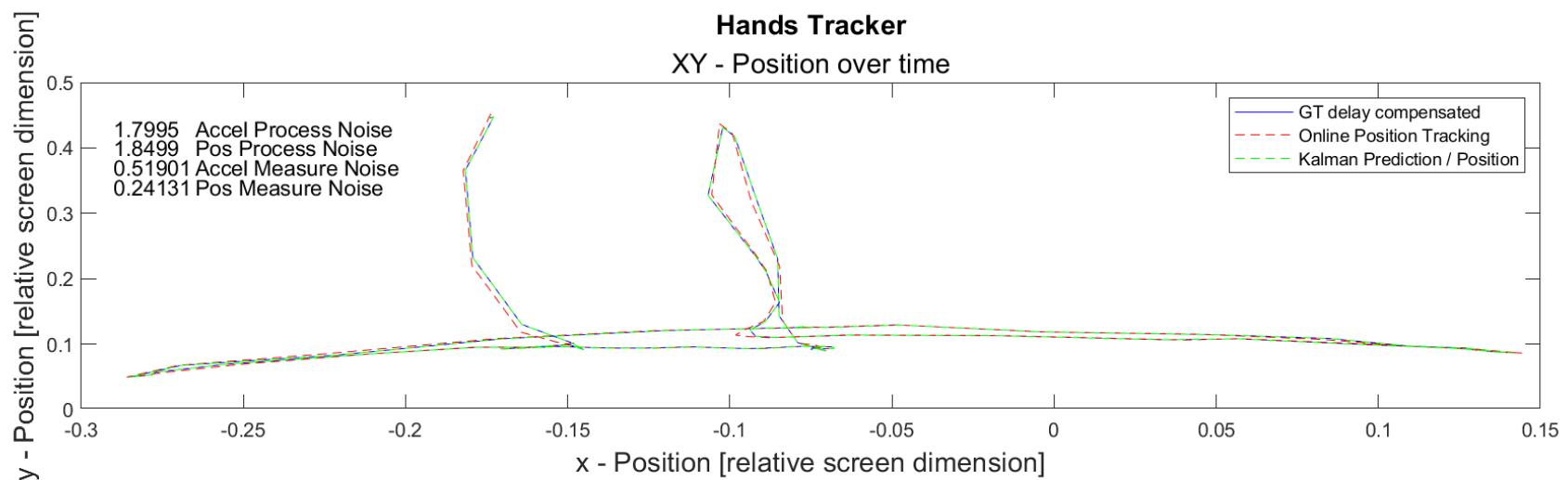
```
1 # me - thi  
2 #  
3 # channel  
4 # sampleRate  
5 # val - th  
6 # prev - t  
7 #  
8 # Make sure  
9  
10 import num  
11  
12 x = 0  
13 P = 0
```

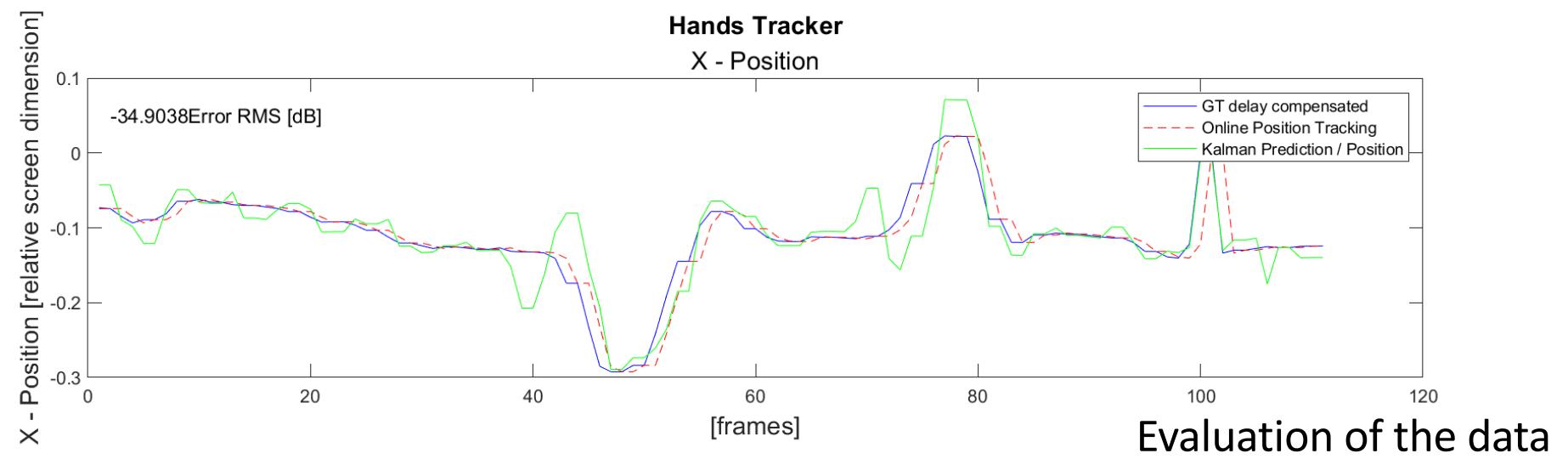
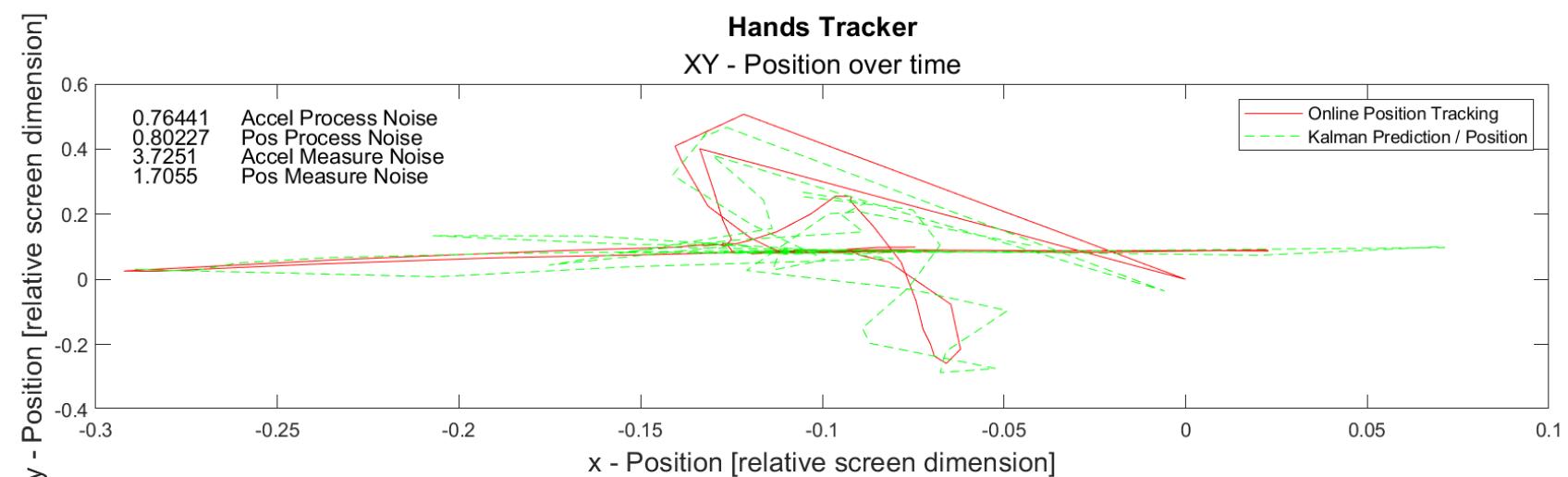
Real data in a real-time setup

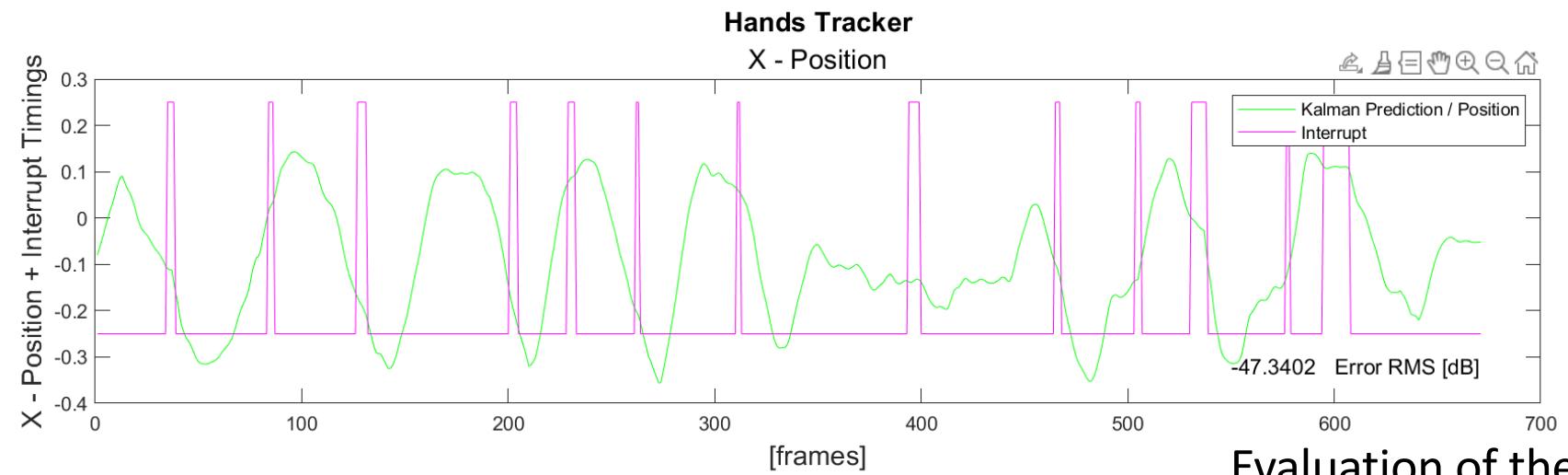
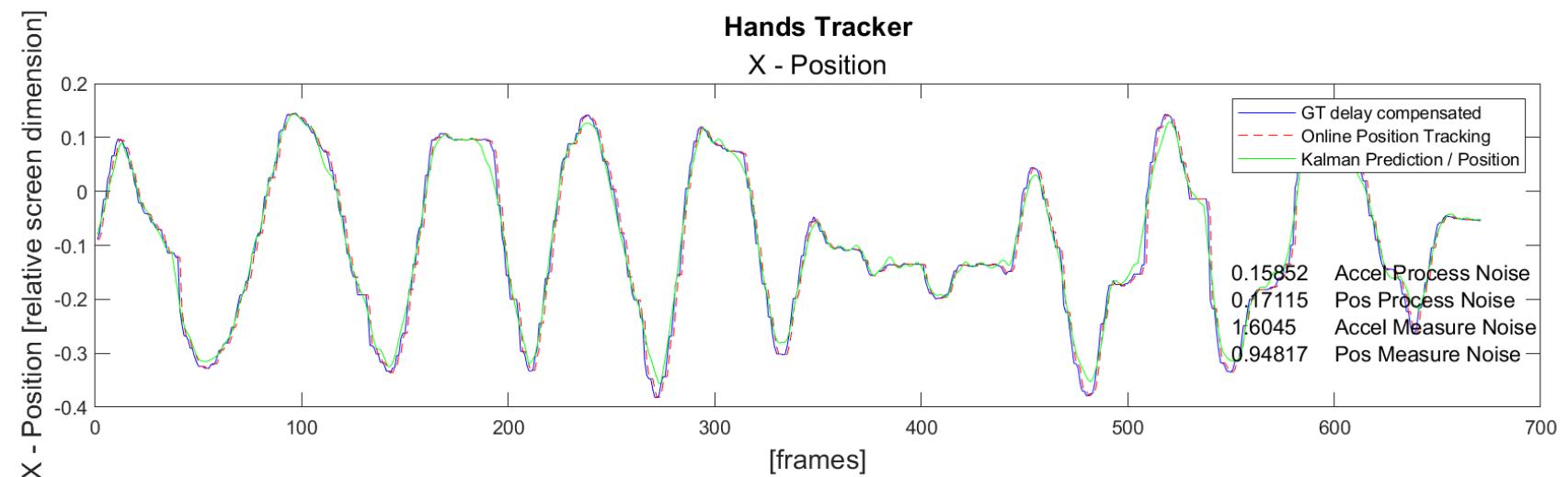


Real data in a real-time setup



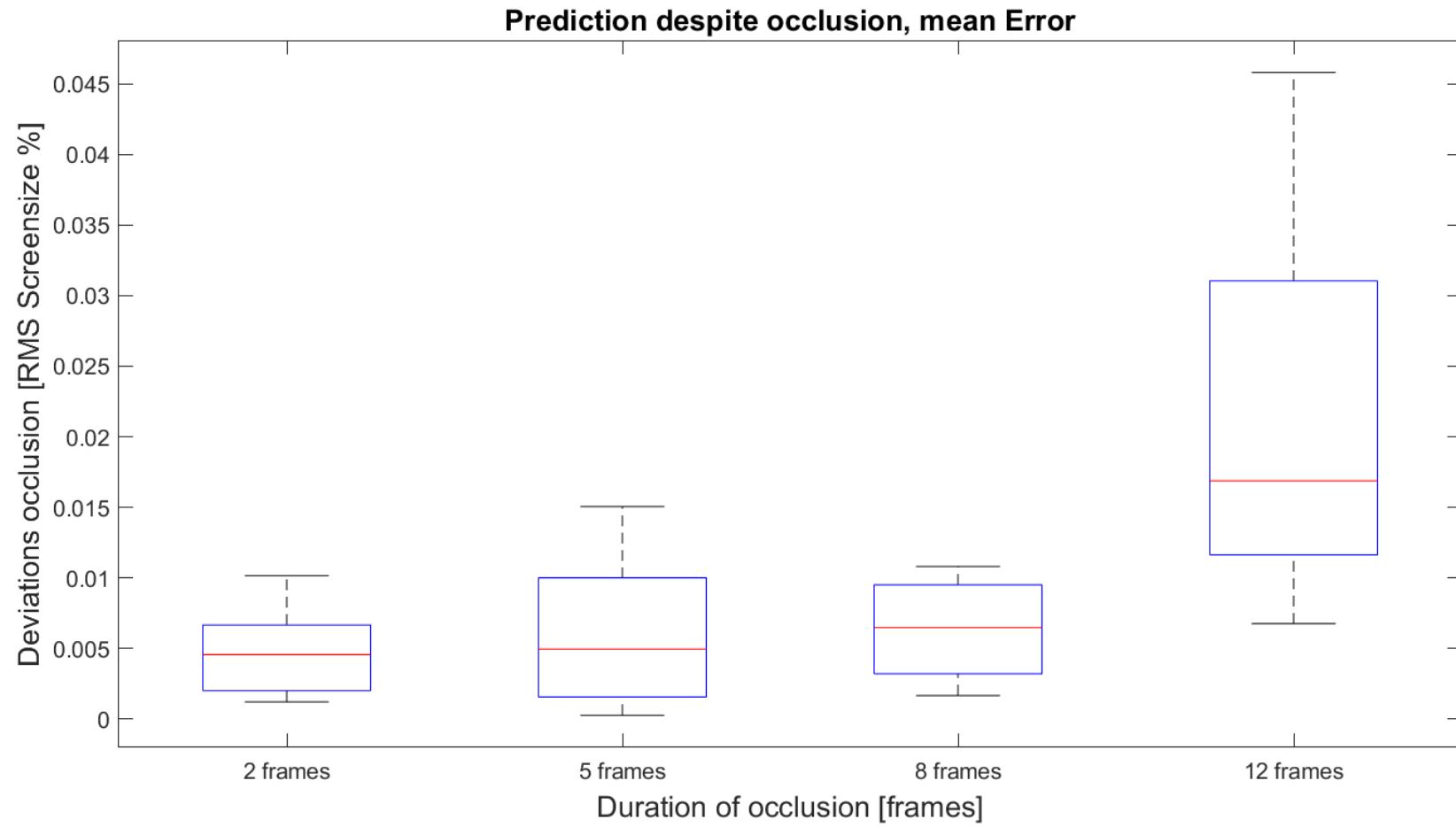






Evaluation of the data

Evaluation of the data



Discussion

- PROs
 - Implementation in real-time
 - Broad learning outcome
- CONs
 - No „real“ Ground Truth
 - No direct connected IMU
 - Really raw data IMU?

Demo

