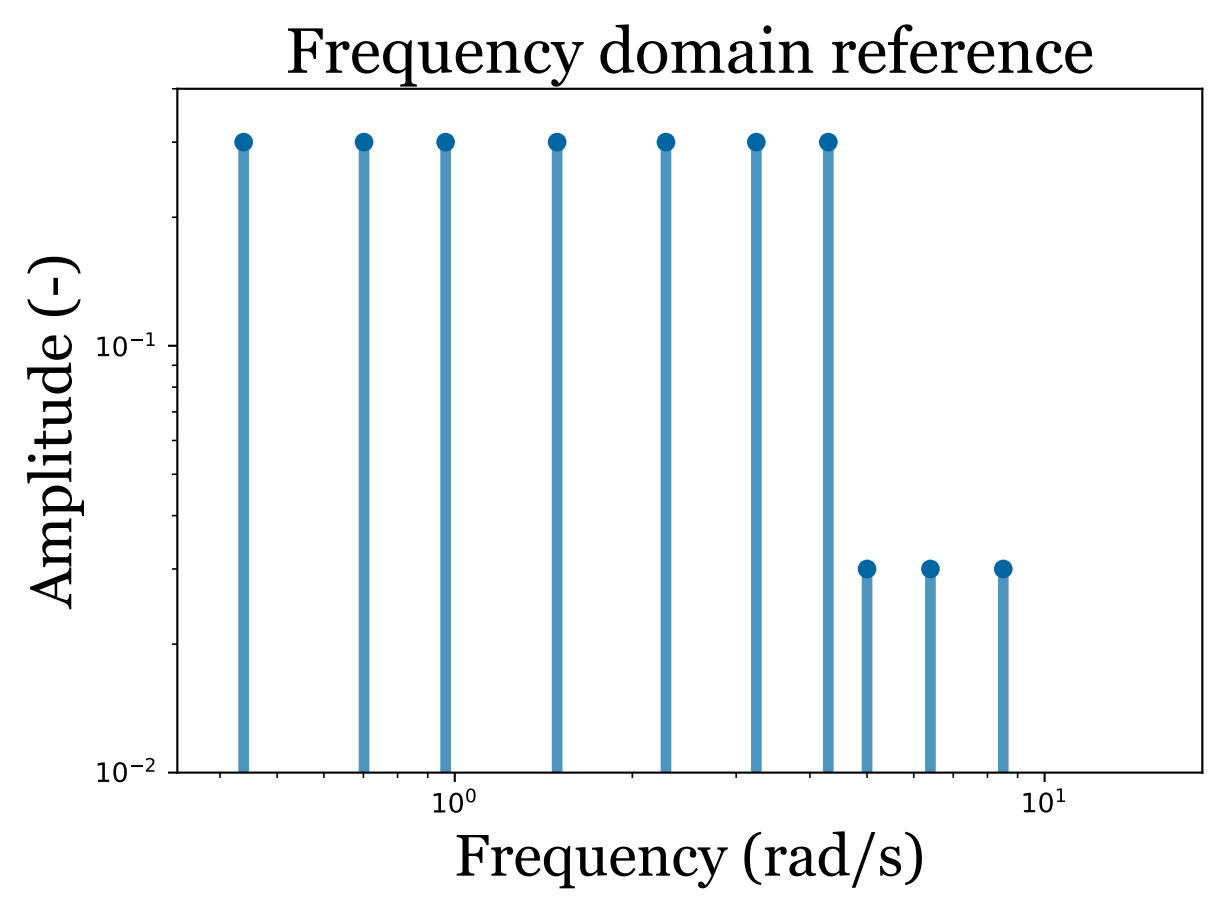
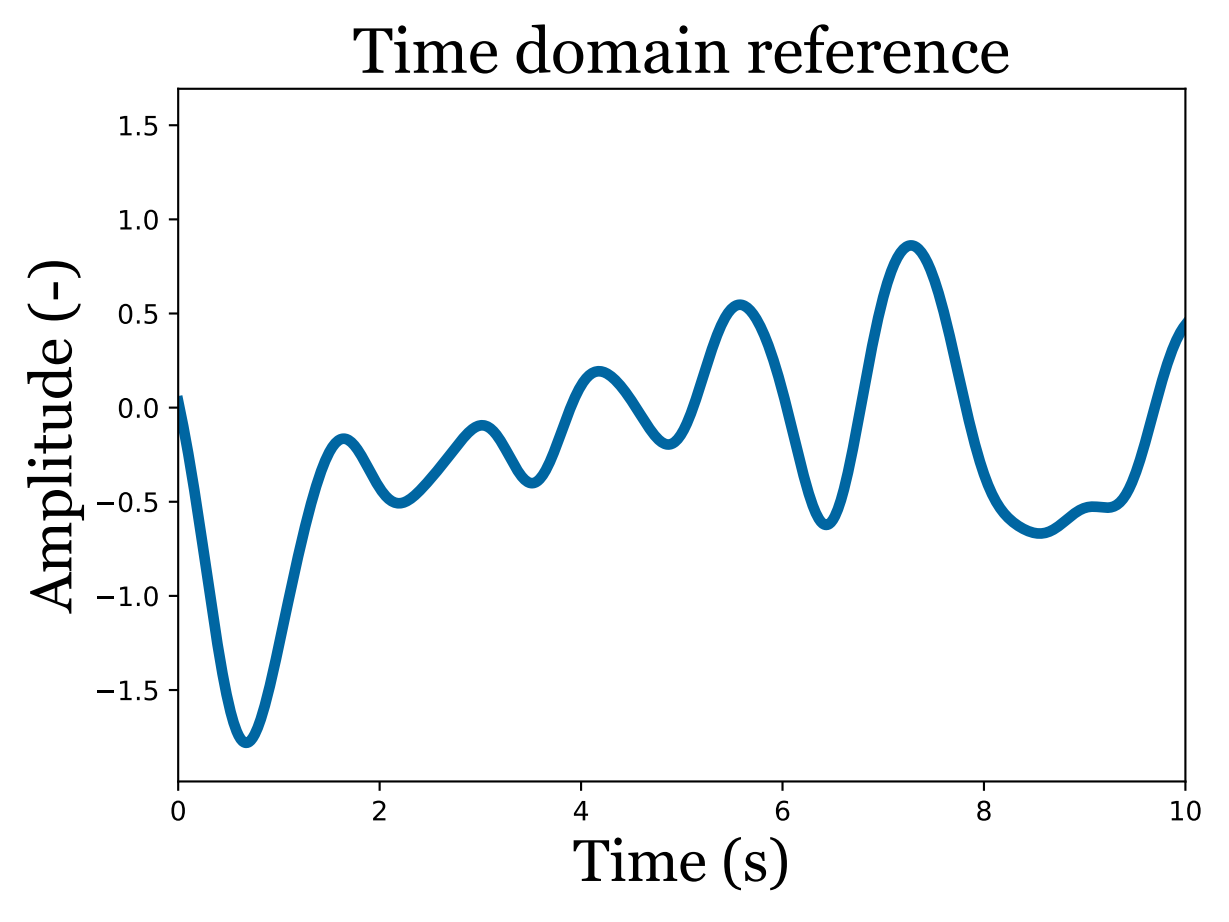
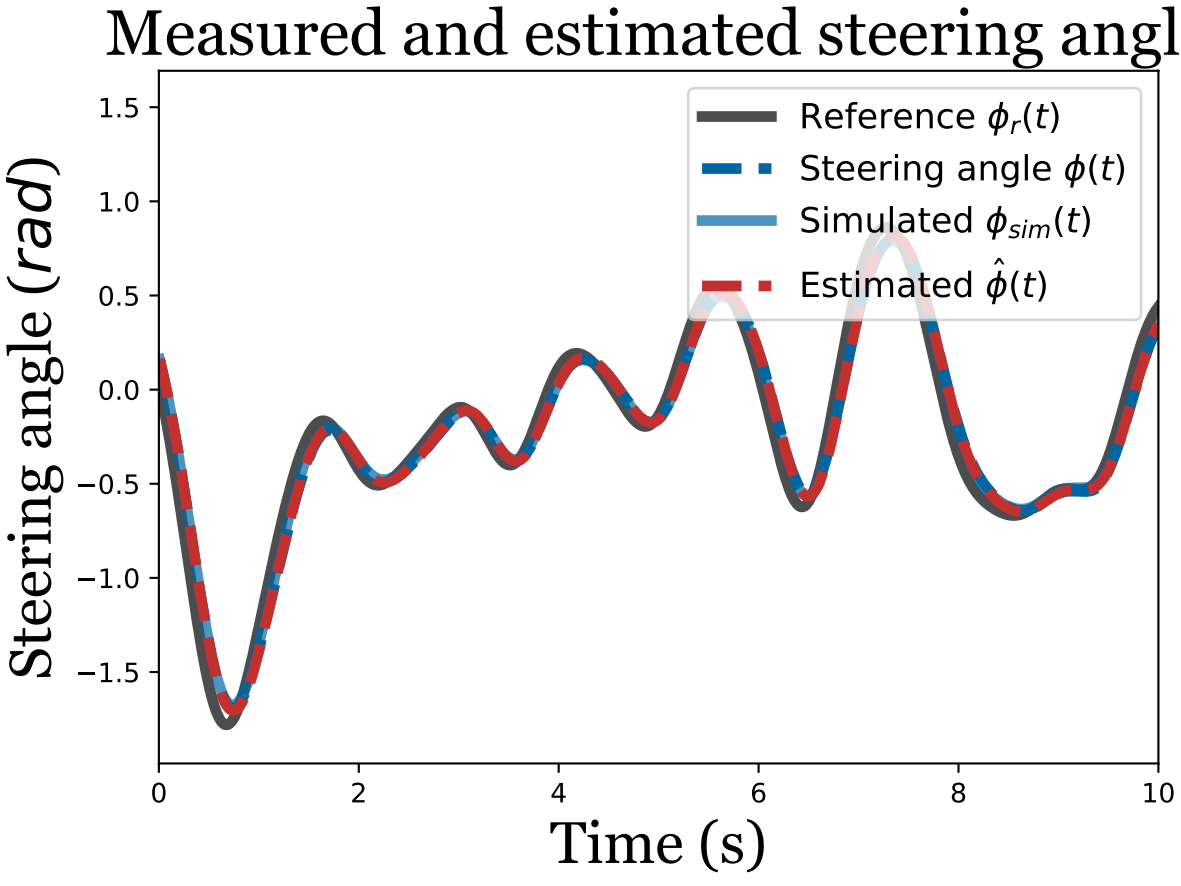
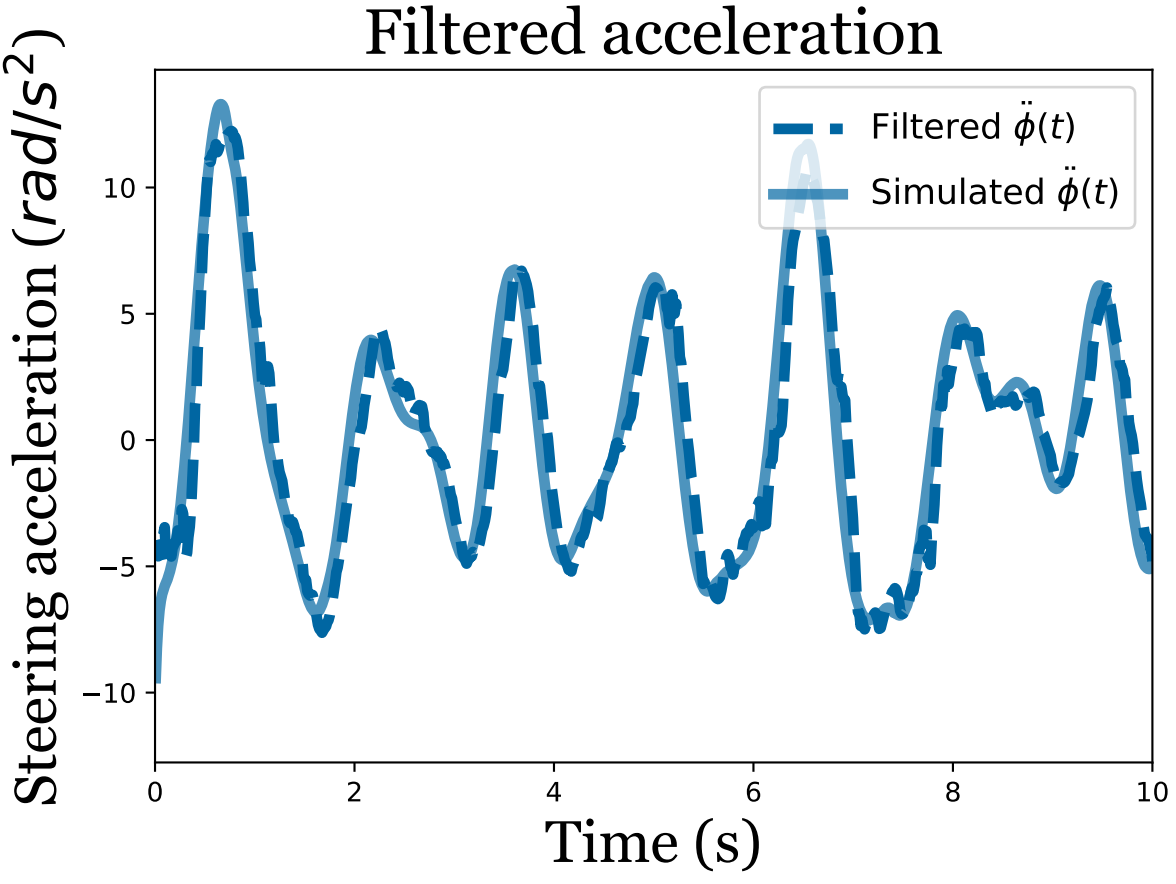
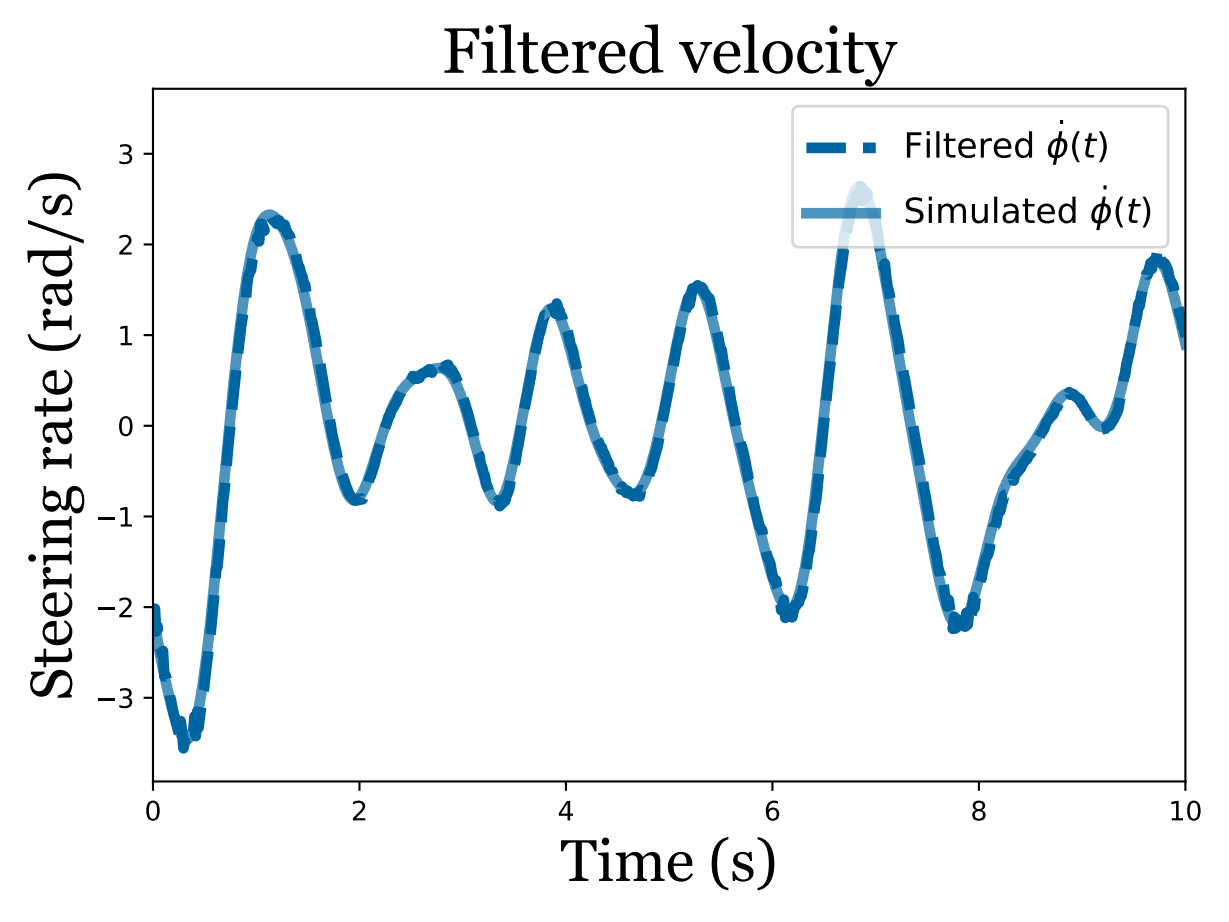
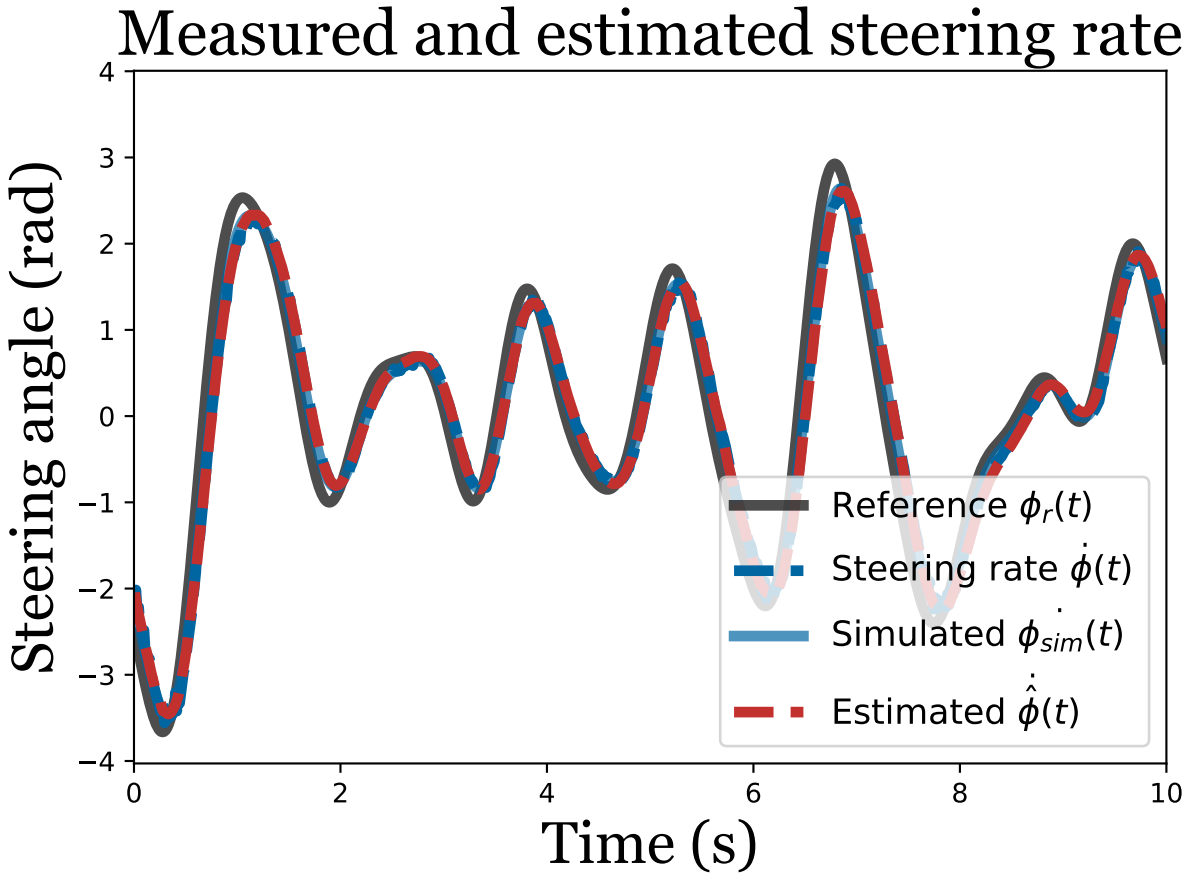

Frequency domain reference
Amplitude (-)
10^{-1}
10^{-2}
10^{0}
10^{1}
Frequency (rad/s)

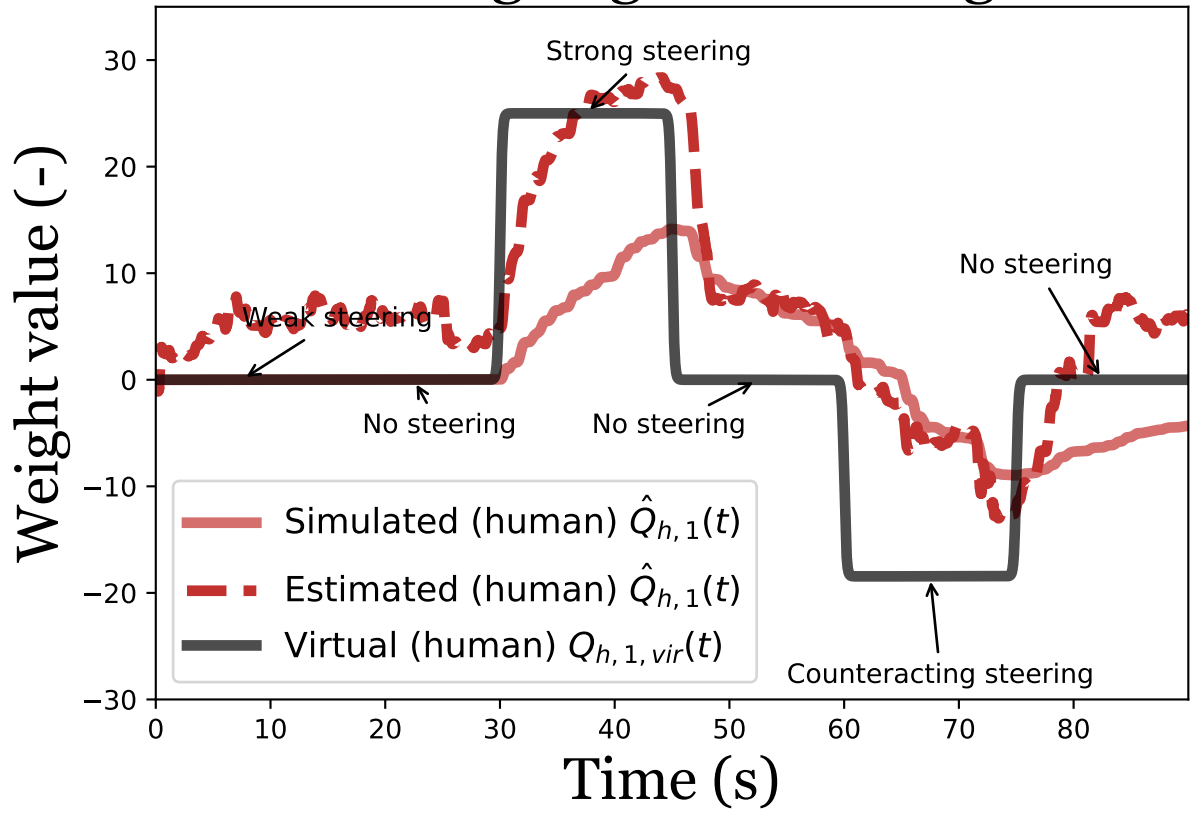

Time domain reference
Amplitude (-)
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
0
2
4
6
8
10
Time (s)

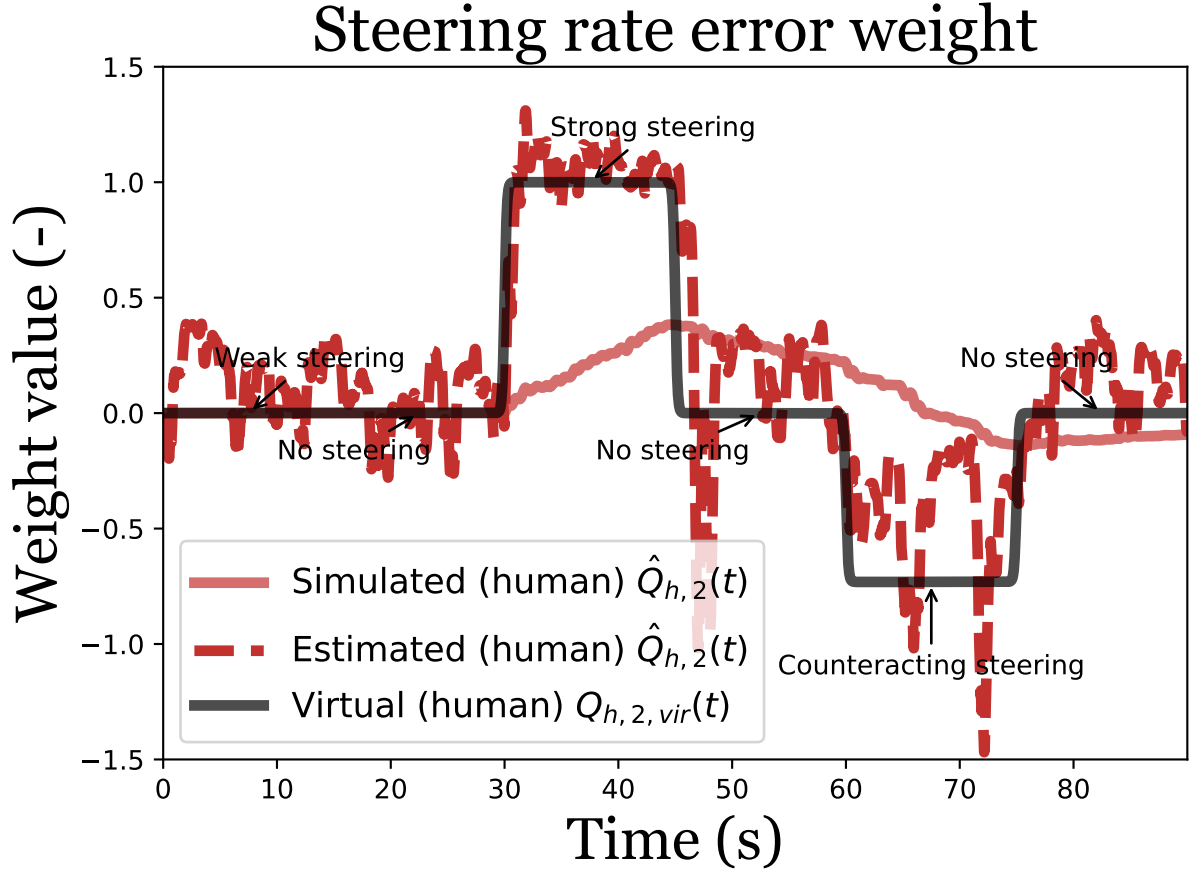

Measured and estimated steering angle
Steering angle (rad)
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
0
2
4
6
8
10
Time (s)
Reference $\phi_r(t)$
Steering angle $\phi(t)$
Simulated $\phi_{sim}(t)$
Estimated $\hat{\phi}(t)$

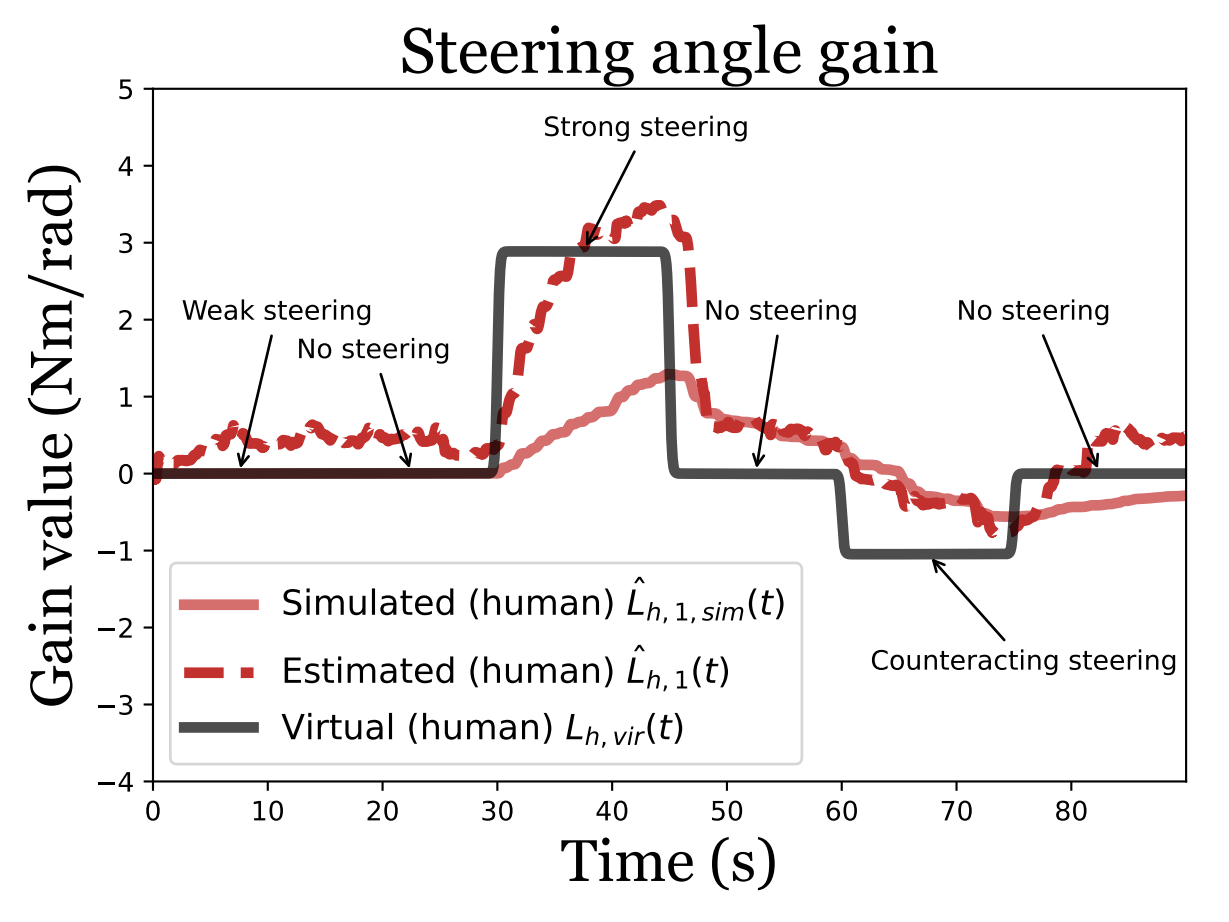

Filtered acceleration
Filtered $\ddot{\phi}(t)$
Simulated $\ddot{\phi}(t)$
Steering acceleration (rad/s^2)
Time (s)
10
5
0
−5
−10
0
2
4
6
8
10

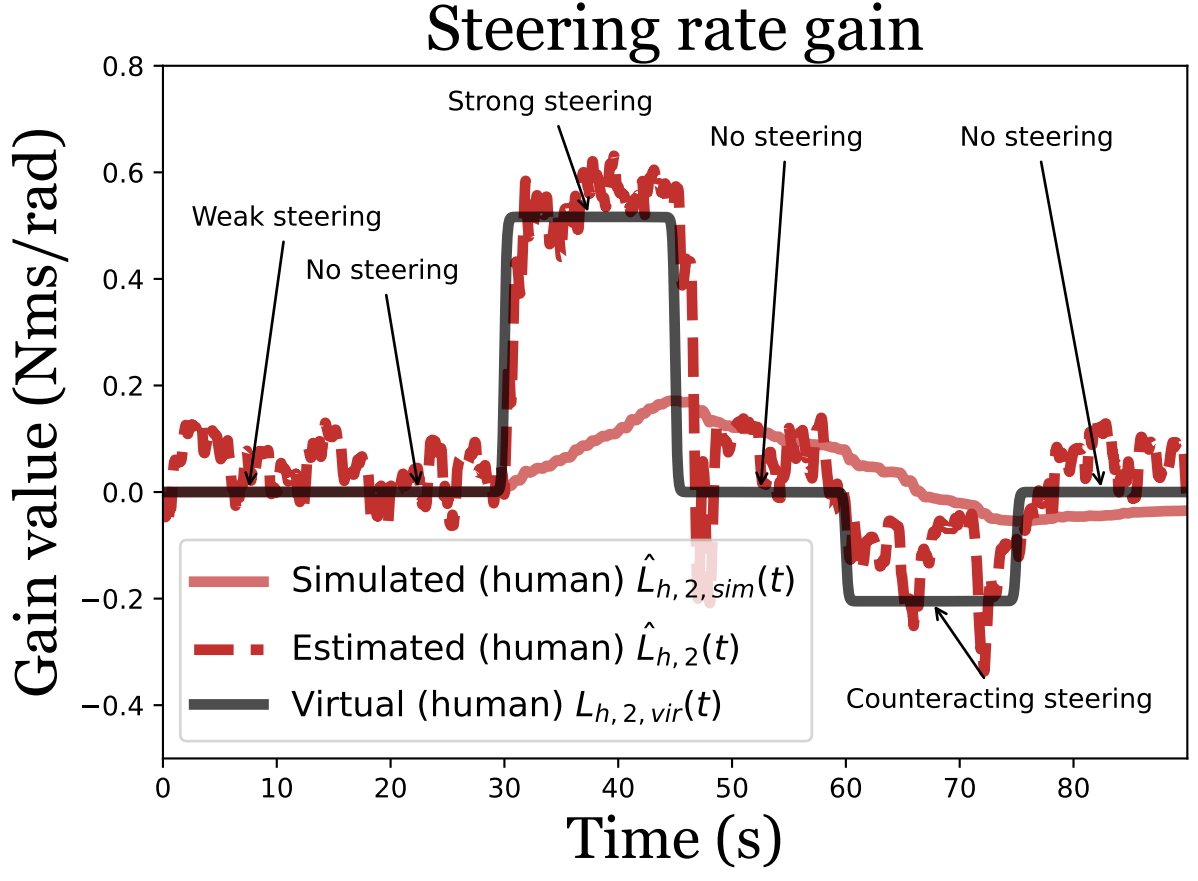

Filtered velocity
Filtered $\dot{\phi}(t)$
Simulated $\dot{\phi}(t)$
Steering rate (rad/s)
Time (s)
3
2
1
0
−1
−2
−3
0
2
4
6
8
10

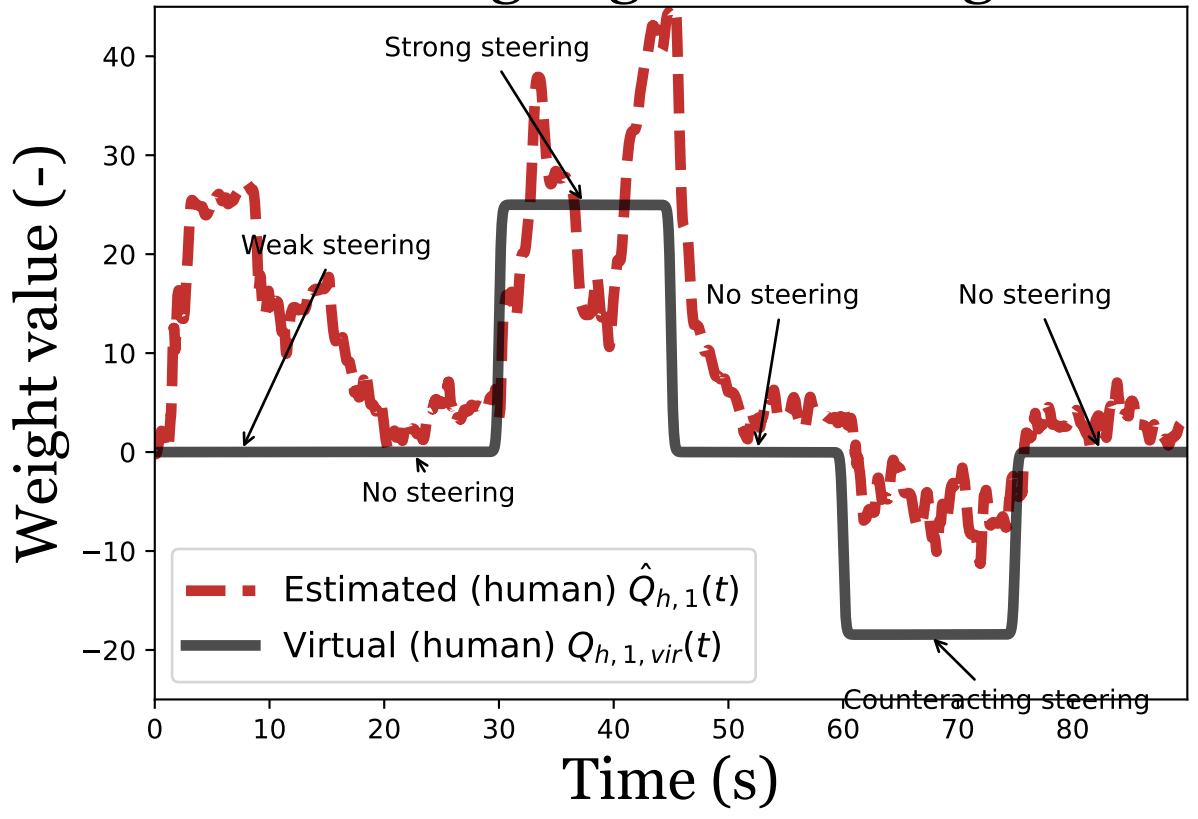

Measured and estimated steering rate
Steering angle (rad)
Time (s)
Reference $\phi_r(t)$
Steering rate $\dot{\phi}(t)$
Simulated $\dot{\phi}_{sim}(t)$
Estimated $\hat{\dot{\phi}}(t)$
4
3
2
1
0
−1
−2
−3
−4
0
2
4
6
8
10

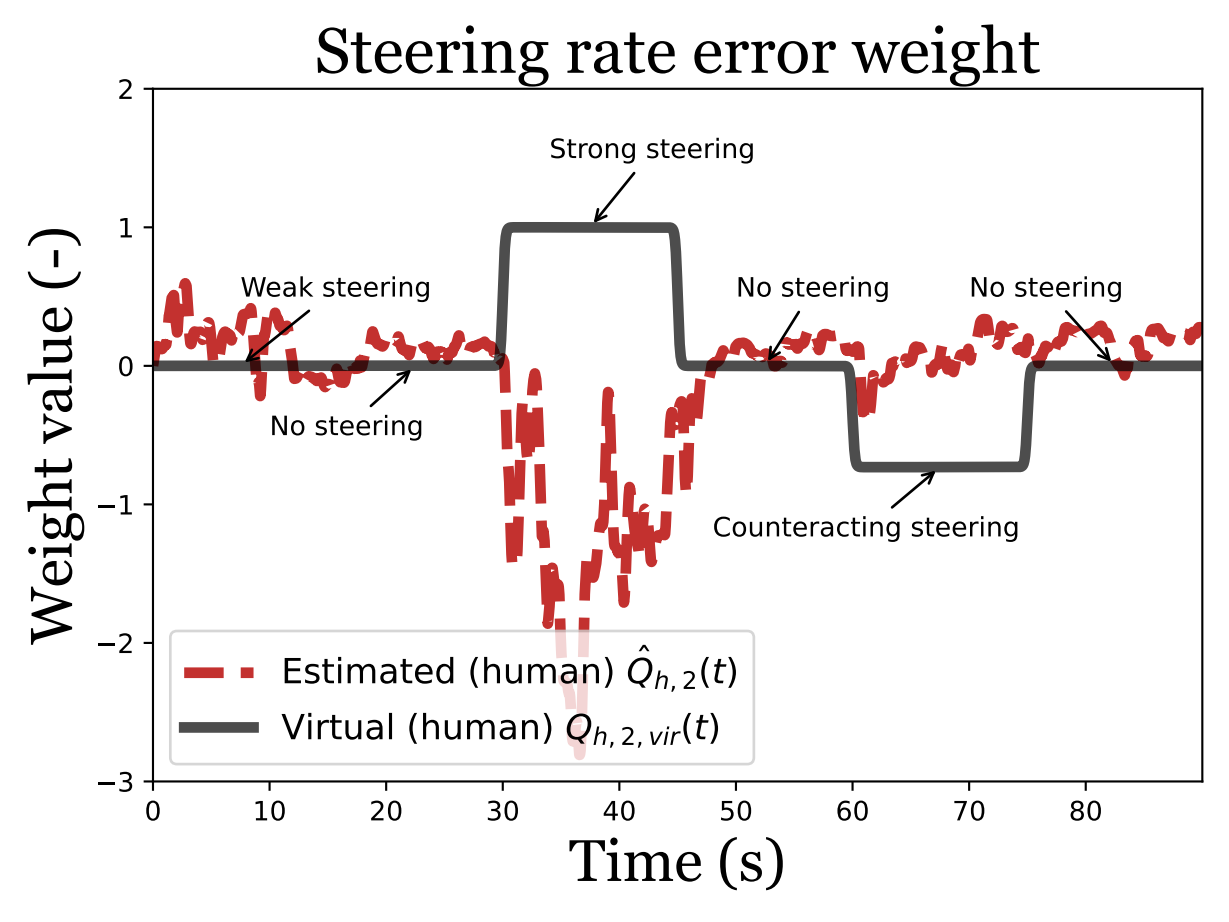

Steering angle error weight
Strong steering
Weak steering
No steering
No steering
No steering
Counteracting steering
Simulated (human) $\hat{Q}_{h,1}(t)$
Estimated (human) $\hat{Q}_{h,1}(t)$
Virtual (human) $Q_{h,1,vir}(t)$
Weight value (-)
Time (s)
30
20
10
0
−10
−20
−30
0
10
20
30
40
50
60
70
80

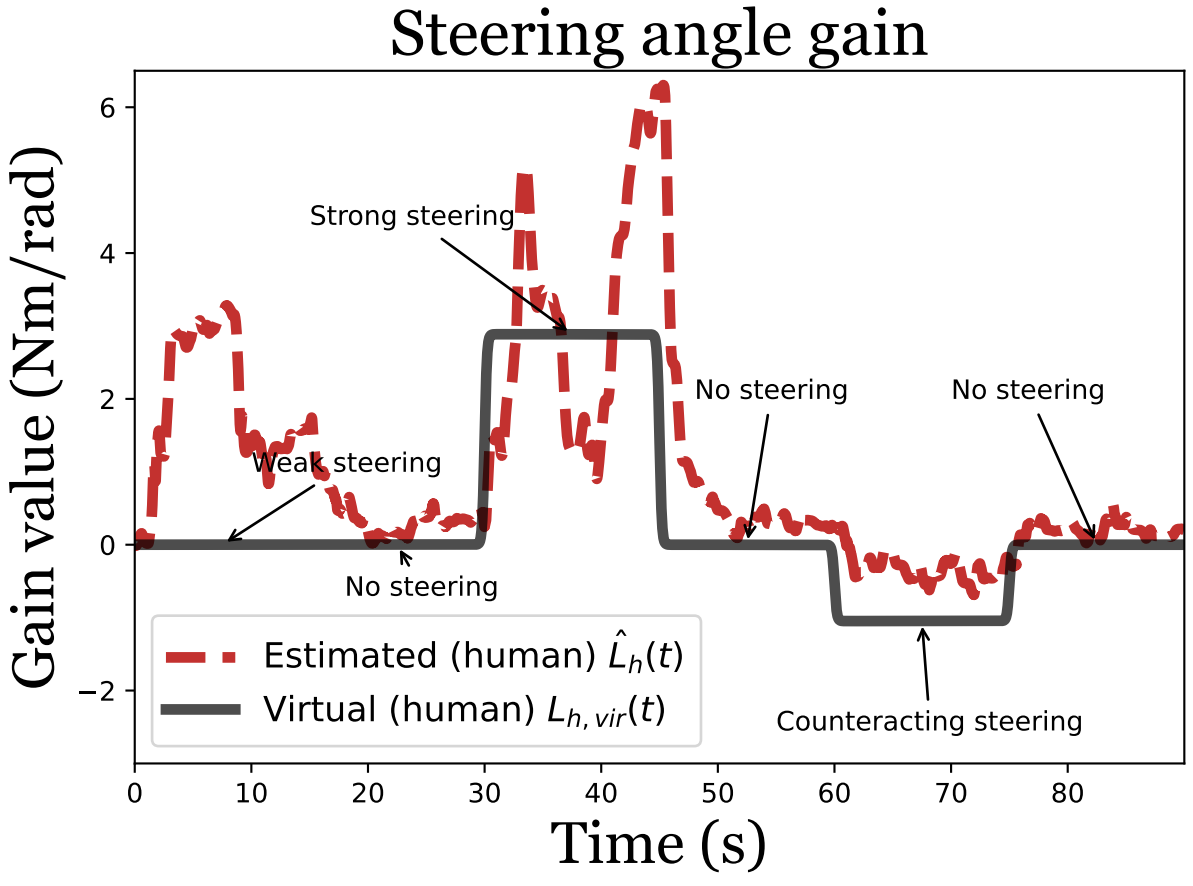

Steering rate error weight
Weight value (-)
Time (s)
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
0
10
20
30
40
50
60
70
80
Strong steering
Weak steering
No steering
No steering
No steering
Counteracting steering
Simulated (human) $\hat{Q}_{h,2}(t)$
Estimated (human) $\hat{Q}_{h,2}(t)$
Virtual (human) $Q_{h,2,vir}(t)$

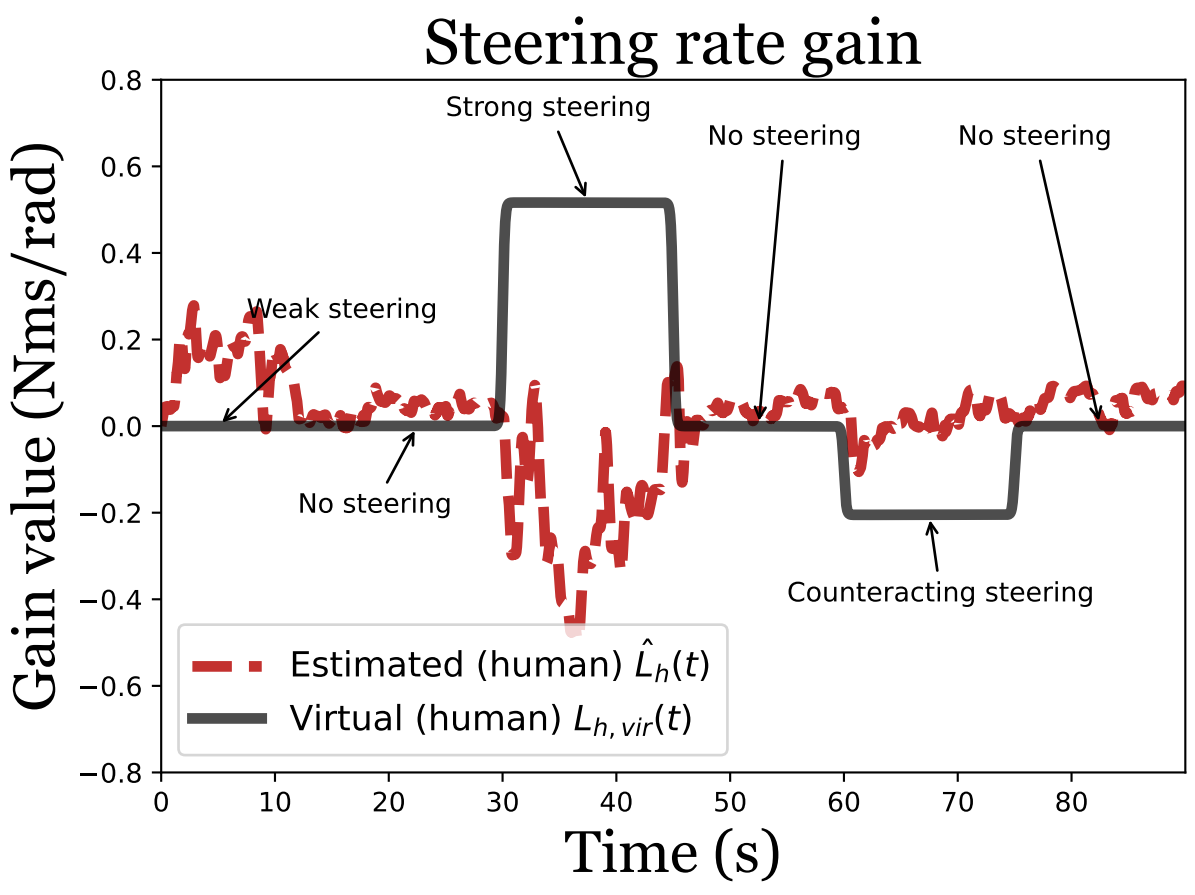

Steering angle gain
Strong steering
Weak steering
No steering
No steering
No steering
Counteracting steering
Simulated (human) $\hat{L}_{h,1,sim}(t)$
Estimated (human) $\hat{L}_{h,1}(t)$
Virtual (human) $L_{h,vir}(t)$
Gain value (Nm/rad)
Time (s)
5
4
3
2
1
0
−1
−2
−3
−4
0
10
20
30
40
50
60
70
80

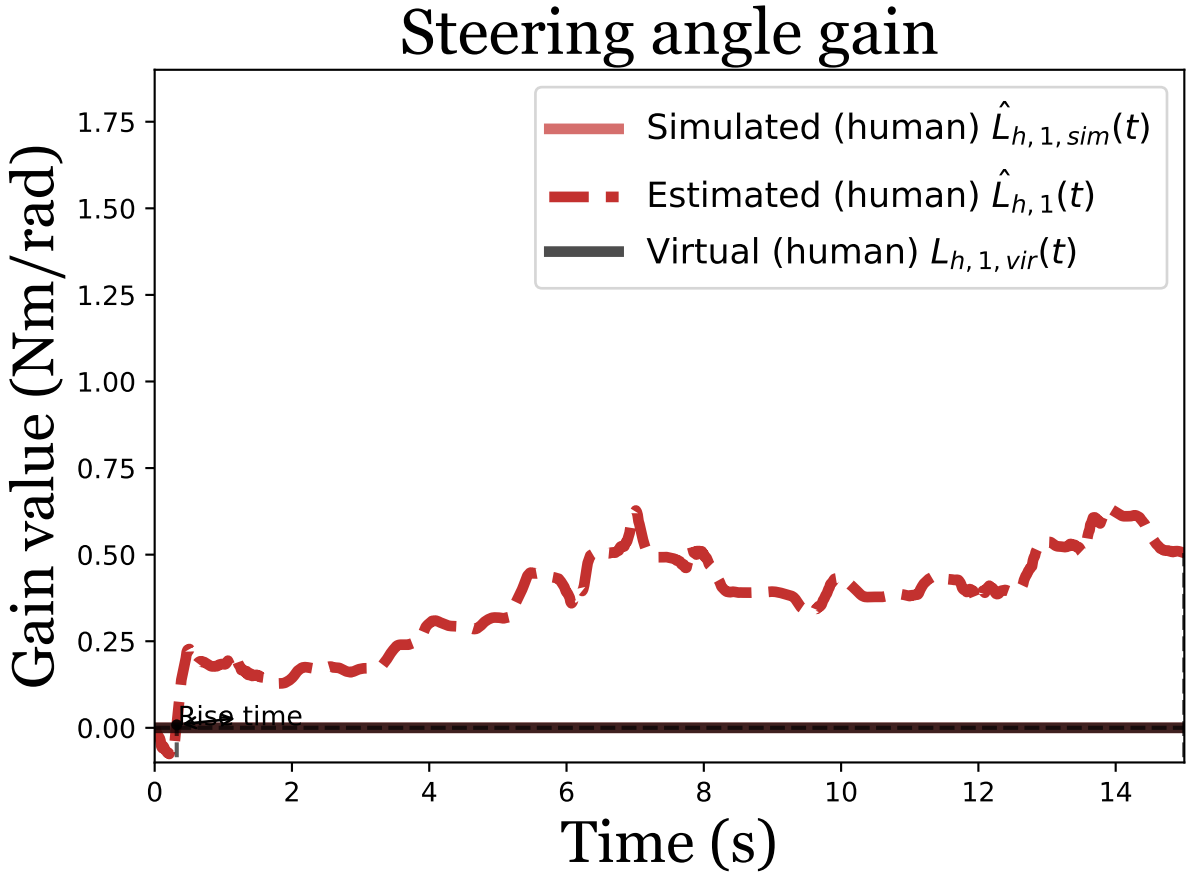

Steering rate gain
Gain value (Nms/rad)
Time (s)
0.8
0.6
0.4
0.2
0.0
−0.2
−0.4
0
10
20
30
40
50
60
70
80
Strong steering
No steering
No steering
Weak steering
No steering
Counteracting steering
Simulated (human) $\hat{L}_{h,2,sim}(t)$
Estimated (human) $\hat{L}_{h,2}(t)$
Virtual (human) $L_{h,2,vir}(t)$

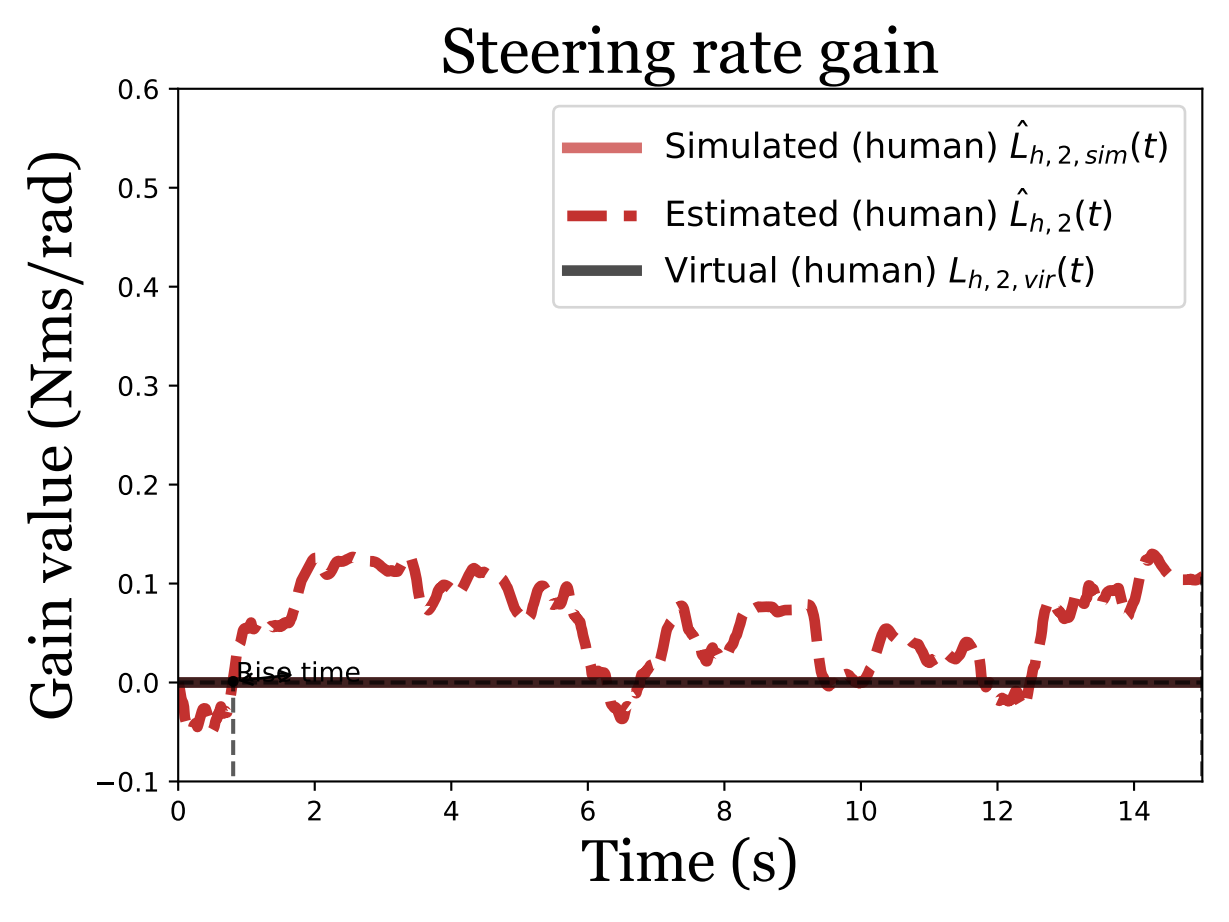

Steering angle error weight
Strong steering
Weak steering
No steering
No steering
No steering
Counteracting steering
Estimated (human) $\hat{Q}_{h,1}(t)$
Virtual (human) $Q_{h,1,vir}(t)$
Weight value (-)
Time (s)
40
30
20
10
0
−10
−20
0
10
20
30
40
50
60
70
80


Steering rate error weight
Weight value (-)
Time (s)
Strong steering
Weak steering
No steering
No steering
No steering
Counteracting steering
Estimated (human) $\hat{Q}_{h,2}(t)$
Virtual (human) $Q_{h,2,vir}(t)$
2
1
0
−1
−2
−3
0
10
20
30
40
50
60
70
80


Steering angle gain
Gain value (Nm/rad)
Time (s)
Strong steering
Weak steering
No steering
No steering
No steering
Counteracting steering
Estimated (human) $\hat{L}_h(t)$
Virtual (human) $L_{h,vir}(t)$
6
4
2
0
−2
0
10
20
30
40
50
60
70
80


Steering rate gain
Strong steering
No steering
No steering
Weak steering
No steering
Counteracting steering
Estimated (human) $\hat{L}_h(t)$
Virtual (human) $L_{h,vir}(t)$
Gain value (Nms/rad)
Time (s)
0.8
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
−0.8
0
10
20
30
40
50
60
70
80


Steering angle gain
Simulated (human) $\hat{L}_{h,1,sim}(t)$
Estimated (human) $\hat{L}_{h,1}(t)$
Virtual (human) $L_{h,1,vir}(t)$
Gain value (Nm/rad)
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Rise time
0
2
4
6
8
10
12
14
Time (s)


Steering rate gain
Simulated (human) $\hat{L}_{h,2,sim}(t)$
Estimated (human) $\hat{L}_{h,2}(t)$
Virtual (human) $L_{h,2,vir}(t)$
Rise time
Gain value (Nms/rad)
Time (s)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
−0.1
0
2
4
6
8
10
12
14