Measurement Noise

Title: Measurement noise trade study
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Summary / Key Takeaways

- The system remains stable for all tested measurement noise levels.
- Estimation accuracy (RMSE) and tracking performance (% overshoot) degrade as measurement noise increases.
- Position noise has a larger impact than velocity noise on both RMSE and overshoot.
- Even with high measurement noise, the PID controller maintains overall stability, but with noticeable performance degradation.
- For best performance, sensor precision should be maximized (low noise levels).

Assumptions / Parameters

- Controller: PID, Ts = 2.5, zeta = 0.7, tau = 0.2
- Sampling Rate: 0.1 s
- Process noise: Q = [1e-4, 1e-4, 1e-3, 1e-3] diagonal
- Disturbances: [zero / step / impulse / bias / random]

Results Table

Parameter / Scenario	Overshoot [%]	RMSE [m]	Notes
Position=0.1, Velocity=0.02	24.79	3.20E-02	
Position=0.1, Velocity=0.1	26.01	3.50E-02	
Position=0.1, Velocity=0.5	19.33	7.30E-02	
Position=0.5, Velocity=0.02	28.42	1.61E-01	
Position=0.5, Velocity=0.1	27.36	1.70E-01	
Position=0.5, Velocity=0.5	34.02	1.75E-01	
Position=1.0, Velocity=0.02	30.34	3.10E-01	
Position=1.0, Velocity=0.1	35.9	3.14E-01	
Position=1.0, Velocity=0.5	23.66	3.32E-01	

Observations / Analysis

- RMSE and % overshoot increase with increased measurement noise.
- % overshoot seems more affected by position noise.
- RMSE seems more affected by position noise.
- RMSE is an order of magnitude larger for greater measurement noise

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Conclusion

- For minimal RMSE and % overshoot measurement noise should be kept to a minimum.