TECHNISCHE UNIVERSITÄT MÜNCHEN
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F O R S C H U N G S P R A X I S

Sensor Noise Modelling of Acceleration and Distance Sensors of the TUM Hyperloop Levitation Module

Problem description:

The implementation of closed-loop control systems such as the magnetic levitation system of TUM Hyperloop necessitates the use of sensors for feedback. However, all sensing devices introduce measurement noise (flicker noise, white noise, etc.) which manifests itself in either performance degradation, or potentially worse, in destabilisation of the system if not accounted for in the controller implementation. Explicitly modelling sensor noise can help predict its impact on system performance and improve controller and filter synthesis.
However, sensor noise characterisation and modelling have traditionally evolved as separate research areas, making it challenging to translate sensor data sheet specifications (e.g., noise density, Allan Variance plots) into a practical simulation implementation [1].
In the first step of this research internship, the objective is to develop accurate sensor noise models in MATLAB/Simulink by identifying the parameters of the underlying noise sources for the given sensors (acceleration and distance sensors). The second step involves validating the implementation through a structured test campaign on the test stand sensors. The overarching aim is to improve the simulation model's fidelity for the TUM Hyperloop magnetic levitation system [2, 3].

Work schedule:

- **Literature Research (3 weeks)** – Survey on noise modelling and characterisation approaches
- **Noise Modelling (2 weeks)** – Appropriate noise modelling of distance and acceleration sensors
- **Simulation (1 week)** – Implementation of chosen models in a simulation
- **Experimental Validation (1 week)** – Validation of models using real sensor data
- **Documentation (2 weeks)** – Summary of findings and performance insights

Bibliography:

[1] Kshitij Jerath, Sean Brennan, and Constantino Lagoa. Bridging the gap between sensor noise modeling and sensor characterization. *Measurement*, 116:350–366, 2018.
[2] Kshitij Jerath and Sean N. Brennan. GPS-Free Terrain-Based Vehicle Tracking Performance as a Function of Inertial Sensor Characteristics. In *ASME 2011 Dynamic Systems and Control Conference and Bath/ASME Symposium on Fluid Power and Motion Control, Volume 2*, pages 367–374, Arlington, Virginia, USA, January 2011. ASMEDC.
[3] Naser El-Sheimy, Haiying Hou, and Xiaoji Niu. Analysis and Modeling of Inertial Sensors Using Allan Variance. *IEEE Transactions on Instrumentation and Measurement*, 57(1):140–149, January 2008.

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