Master Thesis at the Institute of Helicopter Technology

Robust Helicopter Rotor State Estimation for High-Bandwith Control Laws

Rotor dynamics play an important role in the stability and handling characteristics of helicopters. Pilots control inputs to change the fuselage motion take effect after a certain time delay caused by the rotor dynamics. Advanced flight control systems are necessary to support the pilot in difficult missions and alleviate pilot workload. However, the achievable controller bandwidth is limited by the rotor-body coupling phenomenon. The problem is aggravated in hingeless or bearingless rotor systems in which some rotor dynamic modes have high frequency and very low damping making them prone to undesirable oscillations and instability.

One approach to stable high-bandwidth helicopter flight control is to use rotor state feedback in the control laws. The challenge lies in measuring the states in a rotating frame of reference. It is not only technically complex but also commercially infeasible. Control theory offers a robust observer framework to estimate the 'internal states' of a system based on measured outputs only.

Figure 1: TUM Rotorcraft Simulation Environment

Scope of Thesis Work:

We offer an exciting opportunity to work on a high-bandwidth helicopter flight control system for our rotorcraft simulation environment. The thesis will aim to study the theoretical frameworks on state estimation and apply it to higher-order linear state space models of a bearingless helicopter. The student will seek to answer the research question:

- How can the rotor states be estimated robustly and accurately using only the measurements of the fuselage states and a higher-order state-space model?
- How can the estimated rotor states be used in the feedback control laws to improve bandwidth and stability characteristics?
- How do human pilots perceive rotor state feedback control laws?

Skills:

1. Knowledge of control theory and helicopter flight physics is essential
2. Proficiency in using Matlab script and Simulink modeling

Language:

German or English

Start:

SoSe 2021 or ASAP

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