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Fault-tolerant Control of Airborne Wind Energy Systems with Quadrotor/Fixed-Wing UAV Configuration

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Safety, robustness and reliability are crucial aspects of any power generation technology, and airborne wind energy developers have been focusing on them since several years now. Since automatic control plays a key role in AWES, approaches to guarantee continuous operation of the control system shall be adopted. This work considers the AWE configuration Quadrotor/Fixed-Wing hybrid unmanned aerial vehicle (UAV), referring in particular to a prototype from Kitemill AS.

The presentation discusses ongoing research activities to apply Fault-tolerant control (FTC) for AWE tethered flight and to study how it can improve the system reliability and safety. First, a control structure dedicated to Quadrotor/Fixed-Wing hybrid UAV is introduced. The suggested scheme uses daisy chain control allocation [1],[2], which can react instantly in the event of actuator saturation; this is highly demanded in AWE for robust continuous autonomous operation. Then, the mentioned structure is upgraded to Active Fault-Tolerant Control (AFCT) by introducing a quantitative model-based Fault Detection and Isolation (FDI) approach and introducing a new parameter that links the commanded control signals to the system states. This parameter is used to assist residual generation in order to identify the faulty actuator and avoid false alarms, overall improving fault-tolerance measures for the AWE system.

Kitemill's 5kW system considered in this study

References:

[1] Dale E. at al., Dynamic inversion: an evolving methodology for flight control design. International Journal of Control, Volume 59, pp. 71-91, 1994.

[2] T. Mohammed and L. Fagiano, Dynamic inversion: an evolving methodology for flight control design. IEEE Conference on Control Technology and Applications (CCTA), Trieste, Italy, August 2022.