Robust Autonomous Control of Onboard-Generation AWE Systems

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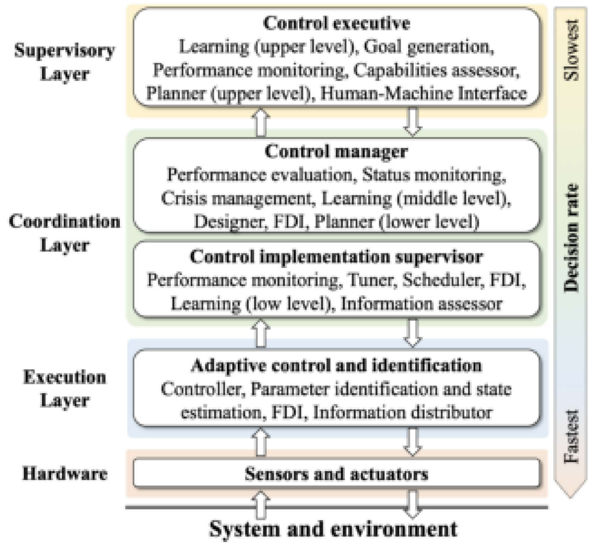
The transition of Airborne Wind Energy (AWE) to an established, industrial-grade power generation solution will require high standards of flight-critical reliability. For onboard generation systems, this challenge is further complicated by the strong coupling between energy harvesting and aerodynamic stability. Moreover, addressing this issue requires control architectures that can cope not only with turbulent wind conditions but also with failures in sensors, actuators, onboard computation, and the ground-based winch system [1].

This presentation outlines a research program to develop a robust and fault-tolerant control framework for AWE onboard-generation systems, targeting catastrophic failure probabilities of the order of 10^{-9} per hour. The approach adopts a modular cascade architecture [2], combining conventional feedback control schemes and nonlinear ones. In such architectures, control actions and decisions are spread across various system layers, from fast low-level execution to higher-level supervision and fault management. The project investigates how robustness can be achieved through a careful design and optimization of safety-related redundancies across sensing, actuation, and computation, specifically targeting the lower layers. As a first step, actuation redundancy are explored through a four-propeller distributed propulsion system on a fixed-wing airframe. The work also considers off-nominal operating conditions relevant to AWE operation, like partial loss of thrust in one of the propellers during the transition or hovering phases. These scenarios are evaluated using a Python-based simulator, with experimental validation conducted on a custom test bench.



Typical hierarchical structure of autonomous systems like AWE [3].

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