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Optimizing Take-off and Landing Control of Magnus Effect-Based Quadcopter AWES in Challenging Wind Conditions

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The take-off and landing phases of airborne wind energy systems (AWES) are critical, particularly in extreme wind conditions. Ensuring the safe operation of AWES during these phases presents a significant challenge. This work centers around the Quadcopter/Magnus effect wing hybrid UAV configuration [1,2]. While less efficient than traditional fixed-wing configurations, the Magnus effect offers increased robustness by enabling precise control over the speed of cylinder rotation to produce the desired aerodynamic forces. Instead of relying on the angle of attack dependent on apparent wind, this control over rotation speed eliminates the complexities associated with wind estimation.

Our presentation discusses ongoing research efforts that employ control allocation strategies for Magnus effect-based quadcopter AWE tethered flight and studies how it can guarantee safe take-off and landing in extreme and turbulent wind conditions. Initially, we introduced a position controller based on 3D robust sliding mode control (SMC) [3]. This foundational structure was then upgraded to a nonlinear constrained optimization-based control allocation strategy. The optimization problem centers around the objective, primarily minimizing power consumption during take-off and landing. This is achieved by giving a higher contribution to the Magnus aerodynamic forces through precise control of its rotational speed while allocating the remaining forces to the drone's thrust.

Our novel control strategy showcases adaptability to various wind conditions, including no wind and high wind speeds up to 20m/s, thus enabling the AWE system to take off safely and land across various scenarios. In experimental tests conducted under different wind conditions, we demonstrate the effectiveness of our strategy.

Magnus effect-based quadcopter system

References:

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