A Study of Aerodynamics of Airflow through a UAV Propeller

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Abstract:

Unmanned Aerial Vehicles (UAVs) or drones are now popular machines used in many fields, including agriculture, surveying, and military missions. Propellers are crucial equipment that generates aerodynamic forces used for propulsion and maneuverability. Although these propellers are commercially available, manufacturers often lack key performance data like thrust and torque at different RPMs, making it hard to choose the best one for a mission. The objective of this study is to simulate the airflow through a UAV propeller using reverse engineering to estimate thrust, torque, mechanical power, and efficiency. The simulation techniques of this study consist of Computational Fluid Dynamics (CFD) and Blade Element Momentum (BEM) theory. Experiments were conducted using a propeller test stand to verify the simulation results. Compared to experimental data between 200 and 4000 RPM, the CFD model demonstrated more accuracy over the BEM. Average CFD errors for thrust, torque, mechanical power, and efficiency were 14.6%, 4.6%, 3.7%, and 11.5% while BEM errors were higher at 25.8%, 13.9%, 18.9%, and 8.6%. The CFD model was more accurate than BEM because it included 3D effects, whereas BEM model relied on simplified 1D analysis.

Keywords:

UAV propeller, Computational Fluid Dynamics (CFD), Blade Element Momentum theory (BEM).