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Optimal Blade Design of Quad-Rotor Air Vehicle Considering Hovering Thrust and Position Disturbance

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Abstract

The present study deals with aerodynamic design optimization of rotor blade shape parameters of quad-rotor air vehicle in hover. The objectives of the present study are to maximize the average value of thrust forces and to minimize the position disturbance during the hovering flight. The present study first considers the aerodynamic interactions among quad-rotors by changing the center distance (CD) between rotors. Once the optimal CD value that produces the least aerodynamic rotor-rotor interaction, the optimal blade shape parameters are then identified to maximize the hovering thrust and minimize the position disturbance. In the present study, there employs a total of 4 blade shape design variables such as blade twist angle, twist initiation position, blade airfoil section type and maximum chord length. The computational fluid dynamics (CFD) analysis is performed using ANSYS-FLUENT.

The optimization process is conducted in the context of approximate meta-model based optimization. The design analysis data is obtained via design of experiments in order to establish the 2nd order polynomial based response surface models under the use of NSGA-II as a multi-objective optimizer. An approximate optimal design solution is numerically validated with its corresponding actual CFD data.