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Title

Control Design for VTOL Aircraft of Lift+Cruise Configuration using Mode-Switching Algorithm

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Abstract

Recently, various configuration for unmanned aerial vehicles (UAVs) have been introduced to meet specific requirements for various missions. Especially, electric vertical takeoff and landing (eVTOL) aircraft has received lots of attention due to the scale-free production of lift, taking advantage of small electric motors. The eVTOL aircraft with lift+cruise configuration have unique characteristics that the rotors for lift, rotors for propulsion, and control surfaces are all utilized[1] , taking advantages of merits of both rotorcrafts and fixed-wing UAVs. Thus, lift+cruise aircraft can perform various missions more easily, but the dynamical model of the aircraft are nonlinear and more complicated than that of typical rotorcraft UAVs.

To deal with this problem, in this study, linearization of the nonlinear model dynamics around operating points is performed. The trim conditions at operating points are calculated by solving constrained optimization problems. Then, for the linearized model, linear quadratic regulator (LQR) control to obtain the optimal virtual control inputs that minimize thrust energy. The obtained virtual inputs are considered as the desired forces and moments, which are generated by the actuators of the lift+cruise model. To determine control inputs of each actuators, three control modes are considered: VTOL, Fixed-Wing (FW), and Full mode. PID Controllers at each mode have been proposed for tilt-rotor UAVs[2]. In this study, control allocation method for three modes which distributes the virtual inputs to each actuator is applied. During the VTOL mode, only the rotors for lift are actuated. In contrast, rotors for propulsion and control surfaces are used throughout the FW mode, and all actuators are operated during the Full mode. Moreover, mode-switching algorithm among three control modes determined by the predefined mission is applied. The proposed method can be applied to various mission profiles, thus enlarging the operational flight envelope comparing to that of the typical rotorcraft.

Numerical simulations are performed to demonstrate the effectiveness of the proposed control design for the lift+cruise VTOL. Vertical and conventional takeoff, hovering, cruising, level flight, and loitering are considered as mission profiles in this study. Simulation results exhibit the control performance of the lift+cruise model.

References

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