NONLINEAR THREE-DIMENSIONAL STATE-SPACE MODELING OF GROUND EFFECT WITH A DYNAMIC FLOW FIELD

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Abstract

In the field of rotorcraft dynamics, it is significant to all that the induced inflow field is well understood and modeled. A large number of methodologies have been developed in the past years, among which the state-space model stands out for its advantage in real-time simulation, preliminary design, eigenvalue analysis, etc. Recent studies have shown success in representing the induced flow field everywhere above the rotor plane even with mass source terms. The implementation of terms with non-zero net mass flow is extremely important for state-space models in practical applications, such as study of rotors with mass sources or ground effect.

This work focuses on the application of a three-dimensional state-space model in representing ground effect by a ground rotor. A nonlinear state-space model is presented and validated by good correlation with results from perturbation theory. Ground effect is evaluated with the rotor at different heights. The steady and dynamic flow fields are analyzed in both linearized and nonlinear forms. Results are compared both with other formulae (derived from flight test data) and with two-dimensional approximations. It is shown that state-space modeling successfully correlates with other approaches in steady-state, while also providing results while the rotor is operating with a dynamic input. A brief derivation is provided as background introduction.