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Modeling and Control of Morphing Air Vehicles

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ABSTRACT

This paper introduces a new morphing aircraft concept whose purpose is to demonstrate a new flight capability: perching. Perching is a bio-inspired maneuver that utilizes primarily aerodynamics – as opposed to thrust generation – to achieve a vertical or short landing. The flight vehicle that will accomplish this is described herein with particular emphasis on its addition levels of actuation beyond the traditional aircraft control surfaces. A computer model of the aircraft is developed in order to predict the changes in applied aerodynamic loads as it morphs and transitions through different flight regimes. The analysis of this model is outlined, including a lifting-line-based analytical technique and a trim and stability analysis. These analytical methods – compared to panel or computational fluid dynamics (CFD) methods – are shown to be particularly ideal for the analysis of a large number of vehicle configurations and flight conditions. The longitudinal dynamics of this aircraft are studied, and several interesting results are presented. Of special interest are the changes in vehicle dynamics as the aircraft morphs from a cruise configuration to initiate the perching maneuver. Briefly mentioned are the ongoing development of a wind tunnel test article and the problem of perching trajectory determination.

INTRODUCTION

One of the major goals of the development of morphing aircraft structures is to enable new missions and new capabilities for aircraft. The most obvious sources of inspiration for these new capabilities are Nature's fliers. The gross extents to which birds morph their bodies allow them to perform maneuvers irreproducible by current manmade aircraft. One such infeasible maneuver is perching. Perching can be described as a high angle-of-attack approach, with the purpose of using the air flow for braking, followed by a planted landing. While vertical landings have been accomplished by rotary and VSTOL aircraft, it is desired to perch using aerodynamics alone, with little input from thrust-generating devices. This will alleviate the need for the heavy, inefficient thrust generators required to land vertically. Thus, perching will be especially useful for small, efficient reconnaissance aircraft, for example.