A Physics-Based Model of Rotorcraft Brownout for Flight Simulation Applications

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Abstract

Rotorcraft brownout, which is caused by the entrainment of dust and ground debris by the rotorwash during take-off and landing, is a critical rotorcraft operational problem. Brownout has accounted for a significant number of military helicopter accidents in Iraq and Afghanistan. Brownout operations affect safe handling due to the reduction of visibility, in addition to potentially leading to severely damaged engine components and rotor blades. This paper describes the development of a physics-based aerodynamic analysis suitable for engineering simulation of rotorcraft brownout conditions. Central to the brownout analysis is a comprehensive free-wake and fast panel model to predict the rotorwash flow field in close proximity to the ground, which is used to drive debris particle entrainment/transport and visual obscuration models to predict the degraded visual environment. Once completed, this analysis may be coupled with any flight simulation environment. Results are presented demonstrating the ability to predict the rotorwash field in near ground operations, as well as qualitative visualization of the brownout encounter in a visual simulation environment.

Introduction

The entrainment and circulation of ground dust and debris during rotorcraft take-off and landing over unprepared fields, often referred to as brownout, represents a serious operational problem for rotorcraft aviation (see Figure 1). Recent experience in Afghanistan and Iraq has heightened the awareness of the impact of reduced visibility on safe rotorcraft operations in brownout conditions. By some accounts, approximately three out of every four helicopter accidents in Iraq and Afghanistan have been caused by brownout [1]. In addition, extended operations during brownout conditions can also lead to damage of engine components and rotor blades. This problem has received considerable attention with recent work focusing on the use of pilot cueing systems to augment situational awareness in the degraded visual environment associated with brownout [2, 3].

Figure 1: External and Interior Views of Helicopter Operations during Brownout Conditions (from [4])

Presented at the American Helicopter Society 62nd Annual Forum, Phoenix, AZ, May 9-11, 2006.