Impact of Wind Disturbances on Vehicle Station Keeping and Trajectory Following

Kenan Cole* and Adam Wickenheiser†

Formation control of unmanned aerial vehicles is a popular topic with a diverse base of control algorithms. While these algorithms have been demonstrated in simulation and in some flight tests, very few of them address the impact of wind disturbances on the system. Even fewer if any address wind over water or a spatially distributed wind field. We use a statistical wind over water model that can be used with a spreading function to produce a spatial wind field for application to any number of vehicles over time. This wind field definition is then used to determine the impact three different wind conditions (mean wind speed = 1, 5, and 10 m/s) have on a quadrotor's ability to 1) station keep and 2) follow a trajectory. Two control algorithms are examined to compare their performance in the wind field: 1) a PID controller and 2) a specific quadrotor controller defined by Mellinger and Kumar that computes the desired body forces and moments to follow a specified trajectory.

I. Introduction

Formation flight of Unmanned Aerial Vehicles (UAVs) is attractive as it increases the capabilities of a single vehicle. This is particularly useful for first response applications, localization and mapping (SLAM), and military applications such as troop accompaniment. Significant work has been done in the areas of path planning and trajectory following for single UAVs.[1–4] The natural extension to this work is to use the same path planning for multiple UAVs with the addition of shape vectors, potential-like functions, or other means to keep vehicles from colliding.[5,6] There are more adaptive control algorithms such as the vehicles aligning their headings either with each other or an imaginary vehicle,[7] holding a consistent shape even with vehicle failure,[8] or using potential-like functions to drive vehicles to desired positions.[9]

While these studies have made strides towards robustness and collision avoidance, they still do not address environmental effects of wind or wind over water. There are some studies that consider wind: for example Bernard, et al.[10] presents cooperative control flight tests in heavy wind where the controller gain values were manually adjusted for the conditions. Jackson, et al.[1] and Nelson, et al.[11] add a simple estimation of wind into their model, but it is a constant value, which does not reflect the turbulence that is also present. Ratnoo, et al.,[12] Escareno, et al.,[13] and Hancer, et

*Graduate Student, Mechanical and Aerospace Engineering Dept, The George Washington University, Washington, DC 20052

†Assistant Professor, Mechanical and Aerospace Engineering Dept, The George Washington University, Washington, DC 20052