Announcing the Final Examination of Bilal Salih for the degree of Master of Science

Title: An Introductory Study of the Dynamics of Autorotation for Wind Energy Harvesting

Wind turbines have been used for decades to harvest wind energy. They are suitable only to work on close to ground, and have several drawbacks that are related to the availability of the wind and the amount of extracted power compared with the cost of construction. On the other hand, there is an abundant wind power that is available at high altitudes. The wind jet streams at high elevations (8-12kms) are pervasive and persistent, and can potentially produce immense wind energy. Even at moderate elevations of 4-5kms, wind power densities are much higher than on ground and more consistent. Consequently, in this thesis research, we investigate the topic of harvesting energy from high altitudes. First, we provide a comprehensive review of two existing theoretical methods that are proposed for airborne wind energy harvesting, the tethered airfoil, and the static autogyro. The latter approach has inherent advantages that warrant further investigation. Autorotation is a well-known phenomenon where a rotor sustains its angular velocity and maintains significant lift in the presence of strong aerodynamic forces and torques generated by interaction with a strong wind field. Autorotation has been researched in the context of free descent of helicopters but has not been considered for energy harvesting. Existing models have mainly focused on statics analysis. In this research, we propose a simple but dynamic model of the Autogyro, with the goal of ultimately realizing an Autorotation Energy System (AES). The focus of our work is to provide a preliminary dynamic analysis of autorotation, which is largely absent in current literature, to explore the possibility of using autorotation for designing a multipurpose system that can simultaneously fly at high altitudes and generate energy from the wind. The proposed preliminary dynamic model is used to generate a simulation platform, which is used to explore the autogyro's rudimentary maneuvers. Extensive simulation results are provided to evaluate the dynamic performance of "AES." Energy harvesting analyses and results are also presented. It is expected that the results will guide the choice of actuations and control that will be necessary for generating combined autorotation and powered flights that would be net energy generating or energy efficient. The research will be relevant for both tethered and untethered "AES" and could also be incorporated into multi-rotor based UAVs such as quadrotors.

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Approved for distribution by Tuhin K. Das, Committee Chair, on March 4, 2014.

The public is welcome to attend.