small Unnamed Aerial System (sUAS) Flight Time Estimation

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Battery life is one of the most important aspects of a small unnamed aerial system (sUAS) to complete any mission effectively. The total flight time can often be heavily affected by the given payload and current weather conditions during any flight mission. Currently, there is no way for pilots to have a reliable flight time estimate despite having only their own experience to rely on any given field conditions and flight mission parameters. A matrix that would aim to provide an estimated flight time by taking mission-specific data from the field and computer simulation would close the guesswork involved and allow more freedom to the SUAS pilots.

The effectiveness and duration of sUAS flight missions are solely dependent on battery life. Two of the major factors that affect overall battery life is windspeed and payload. For our purposes, two assumptions are made. First, the sUAS is conducting flight missions with no sudden turns. Second, eighty percent of the mission flight is where the sUAS is following a linear path at a constant velocity. Windspeed is often a variable that is conditioned to change due to atmospheric turbulence, wind gust, and wind shear conditions. This affects the sUAS greatly as the sUAS must constantly adjust its power propulsion output and angle of attack (pitch/roll) to keep on its intended flight plan, thus consuming more than usual amounts of battery power. The next big factor is the weight of the payload which also contributes to the sUAS battery consumption through its propulsion system. As of today, no system exists to advise pilots how these two factors in combination will affect the total battery life during the mission. By considering the total amount of power output of the battery with the total estimated work required for the mission, this matrix will be able to provide pilots in the field with an estimate of the time the battery life under ever-changing wind conditions.

In order to create this estimation matrix, we first approach assessing the pitch and roll effects of sUAS voltage consumption by conducting field experiments and computer simulations. The sUAS platform being used in this research was a FoxTech Hover1. It was chosen due to its endurance and its modular capability. The Hover1 will be outfitted with a pixHawk2 autopilot system, complete with Here+ GPS receiver based on UBlox M8P. The pixHawk2 cube comes with a triple-redundant IMU that will be used in measuring the pitch and roll position of the aircraft throughout this report. As well, the Hover1 will be fitted with the Holybro APM Power Module voltage meter throughout the research. For providing useful data given our goals and conditions were testing in the field. To do this we devised three flight plans, all in reference to the wind: parallel, perpendicular, and a combination pattern. For these flight paths, we're going to repeat them from 4 to 20 meters (m) in increments of 4m in hope of seeing any effects from the boundary layers effect on the sUAS power consumption. The flight paths were generated according to current weather predictions and historical wind-rose data from Castle Airport, CA.

For the simulation section of the research, we will be using OS4 quadrotor which is a classic quadrotor simulation platform created on MATLAB & Simulink. The program was built on a multirotor flight dynamic, where the sUAS rotation and positions are calculated from the inputs such as the motor angular velocity. However, OS4 doesn't have a model for voltage consumption, nor a battery model, thus we need an energetic model in order to have an idea about the power consumed by the sUAS vehicle during the flight mission and to provide a direct relationship between energy and vehicle dynamics. This is can be modeled from a simple first-order differential equation due to the relationship between motor torture [Nm], current[A], and torque constant [Nm/A]. A Li-ion battery model was presented by a current input. The output will be voltage and state of charge; however, this model will not account for temperature, nor self-discharge from the battery. As well, OS4 doesn’t have a wind simulator for this we use MATLABs built-in blocks such as Dryden Wind Turbulence, Discrete Gust, and the Wind Shear Model to create the necessary wind environment.

The results from the simulation will act as a baseline for how the sUAV system should act in the field, whereas the field data will be used to not just verify the simulator but to fill the gap of any parameters we missed in the simulator. Once done we will create an app where it will be able to estimate the time on the Foxtech Hover 1. For the future, the app will support multiple platforms taking in these factors from the users to quickly provide them with the estimated flight time.