Wind Estimation on a Quadrotor

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Gas Distribution Mapping and Gas Source Localization provide a better understanding of how gas is distributed in the environment. These are important tools for environmental monitoring or security applications as for example localizing gas leaks. Having some information about the wind improves these algorithms. For these reasons, this project aims to determine the wind intensity using only internal sensors of a Crazyflie drone.

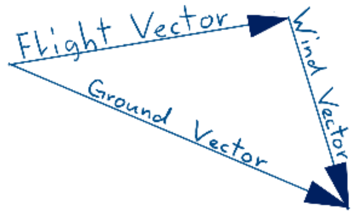

Figure 1: Wind Triangle

The method from Neumann and Bartholmai [i] is used: It estimates the wind intensity by using the wind triangle. The wind triangle is composed out of three vectors (see Figure 1): The flight vector is the flight speed that the drone is intended to have. The wind vector is the disturbance pushing the drone in the direction of the wind. Finally, the ground vector is the sum of the two and the actual speed that the drone has with respect to the ground.
Two entities are measured by the motion capture system: the roll/pitch angles and the position of the drone. With help of the position the ground vector can be derived. By using the roll/pitch angles the inclination angle is calculated. Then, on the basis of the inclination angle the flight vector is estimated. However, first the relationship between the inclination angle and the flight vector has to be known such that the wind intensity can be estimated in real time.
The objective of the first experiment is to establish a relationship between the inclination angle and the flight intensity. Therefore, the drone is hovering for 20s in a wind tunnel under a well defined wind intensity that is measured using an anemometer. Simultaneously, the inclination of the drone is measured. Figure 2 shows the result of five repetitions for different wind speeds. The inclination angle seems to be proportional to the wind intensity.

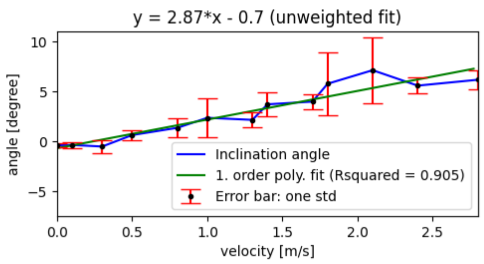

Figure 2 – relationship between inclination angle and flight vector

Further, some validation flights are done to test the accuracy of the wind intensity estimation when using the results of the previous experiment. Two configurations with different flight trajectories are tested for 8 different wind speeds. The average RMSE error is shown in Table 1. The following can be concluded:

- The relationship between the inclination angle and the flight vector is linear.
- It is better to use pitch data than inclination angle data to determine this relationship.
- Using an unweighted model for fitting (every measurement point has the same weight no matter of its variance) gives a smaller RMSE error.

RMSE (m/s)	***Taking off/ Landing***	***Hovering***	***Flying***
Config 1	*0.57*	*0.44*	*0.64*
Config 2	*0.44*	*0.35*	*0.55*

Table 1 – RMSE error of validation flights