Development of a Control Algorithm with Kalman Filter enhancement to control the altitude of a Quadcopter.

A red and white logo

Description automatically generated

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# Abstract

# **Introduction**

In this lab, we embark on the task of designing an estimation and control system for the "Bzzz" quadcopter, as depicted in **Figure 1**. The objective is to develop a robust system that enables the quadcopter to maintain a constant altitude, regardless of external factors and disturbances. To achieve this, we leverage a combination of sensors, including a time-of-flight (ToF) sensor, a barometer, and a global navigation satellite system (GNSS) sensor.

A drone with instructions on it

Description automatically generated with medium confidence

Figure 1 Picture illustrating the Bzzz quadcopter.

The ToF sensor provides measurements of the distance from the ground with a standard error of ±6 cm, while the barometer estimates altitude with an error of ±25 cm. Additionally, the GNSS sensor, coupled with a base GNSS station, offers precise altitude estimates with a standard error of ±5 cm. These sensors serve as crucial components in our estimation framework, allowing us to accurately infer the state of the quadcopter.

To model the dynamics of the quadcopter, we consider the forces acting upon it, namely the weight \(mg\) and the force exerted by the propellers \(F\_{\text{prop}}\). Through experimentation, we establish a model for the lifting force *F*prop​= *ατ*+*β*, where *α >* 0 and *β* < 0 are constants dependent on the battery's charge level. Utilizing this model, we derive the quadcopter's dynamical equations, enabling us to predict its vertical acceleration and velocity.

With our system model in place, we turn our attention to estimation. Employing the Kalman filter, we aim to estimate the unknown parameters *α*and *β* while simultaneously inferring the quadcopter's state variables, including altitude and velocity. Leveraging sensor measurements from the GNSS, ToF, and barometer sensors, we construct an estimation system capable of accurately tracking the quadcopter's state despite uncertainties and disturbances.

Furthermore, we design a control system that utilizes the altitude estimates obtained from our Kalman filter to enable the quadcopter to maintain a constant altitude. Our controller adjusts the throttle reference signal sent to the quadcopter's motors, ensuring precise altitude control in various scenarios, including sudden changes in altitude, GNSS signal interruptions, battery drainage, and sensor biases.

In this report, we present our proposed estimation and control system, along with experimental results demonstrating its effectiveness in diverse real-world scenarios. Additionally, we discuss the rationale behind our parameter choices and provide justifications for our design decisions. Through rigorous testing and analysis, we aim to validate the performance and reliability of our estimation and control system for altitude hold in quadcopters.