Modeling, controlling, and flight testing of a small quadcopter

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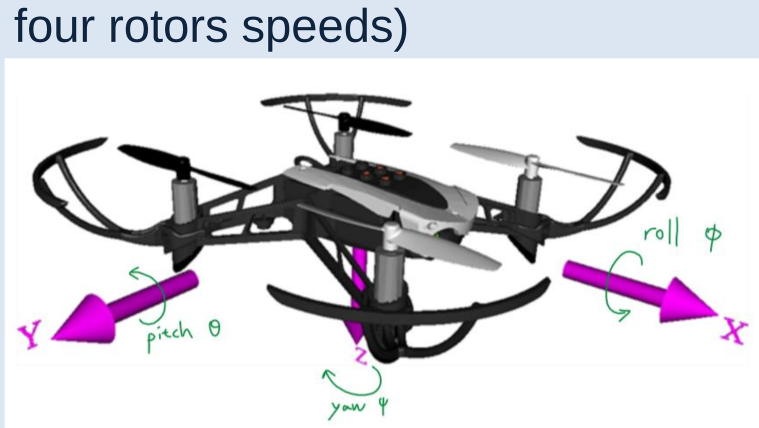
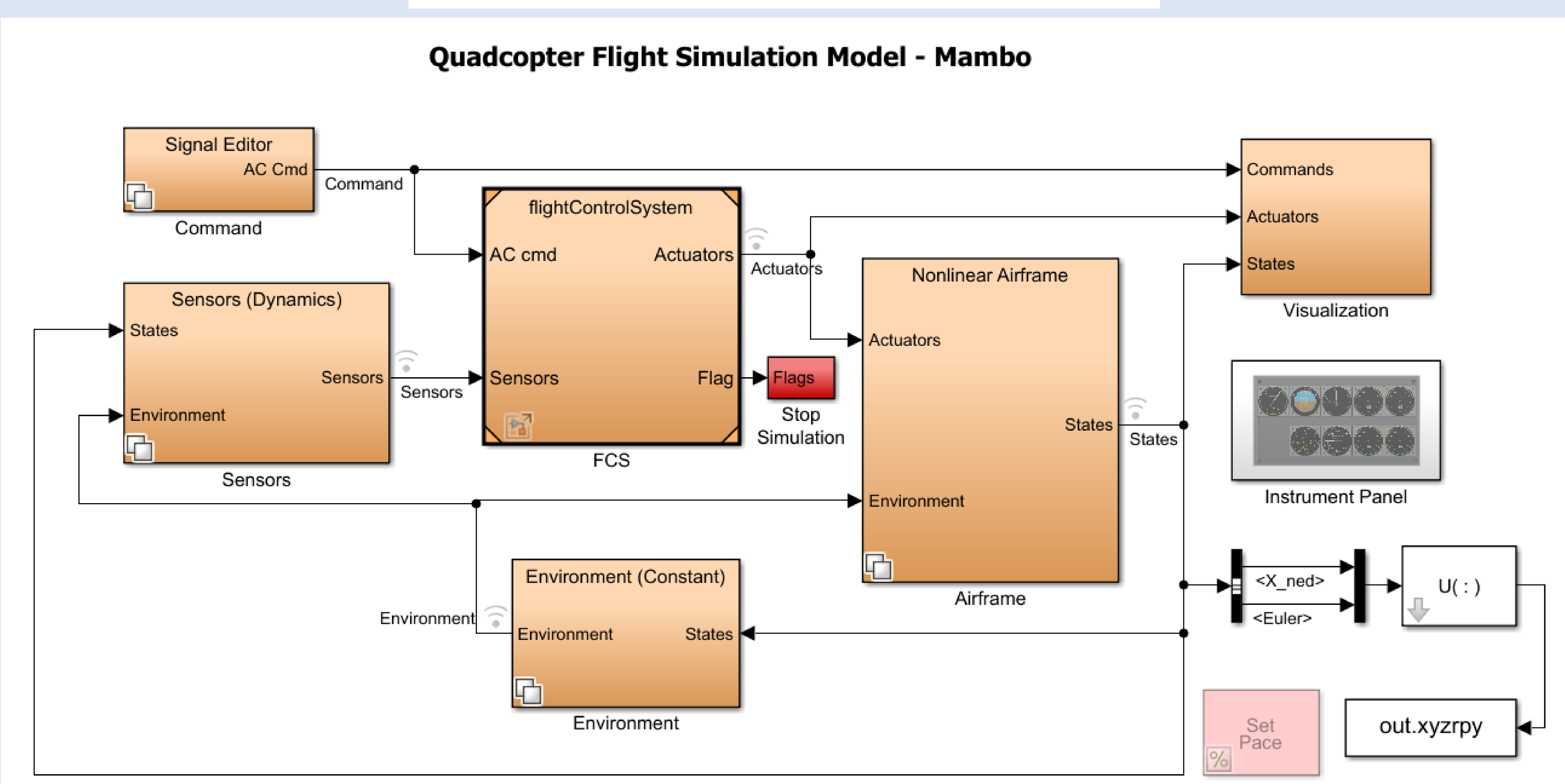
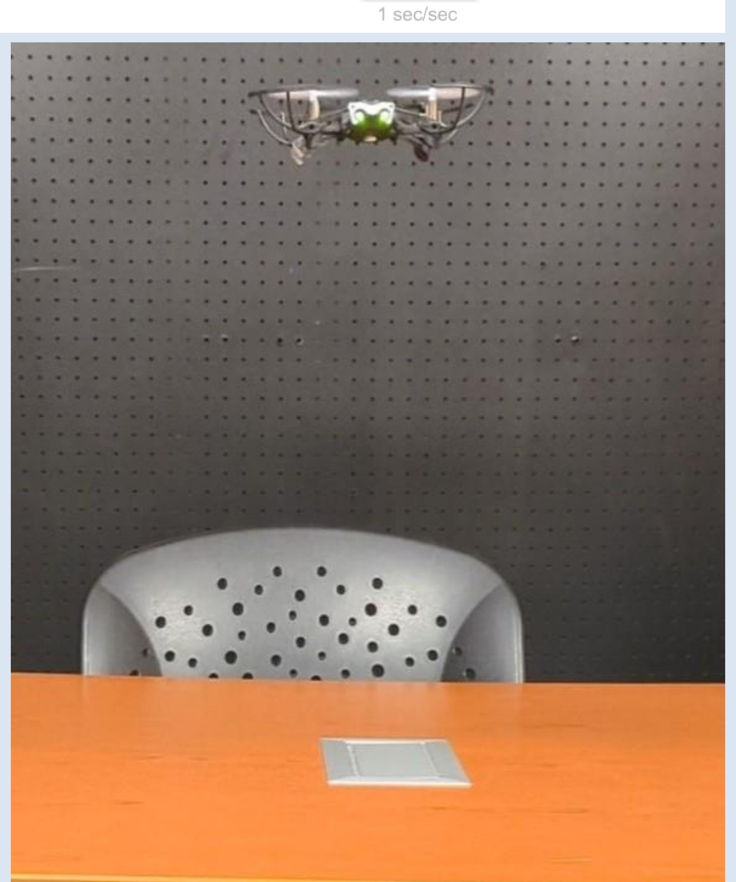
Introduction

- A quadcopter's motion in space is completely determined by the spinning speeds of its four rotors
    - Two of the rotors spin clockwise
    - Two of the rotors spin counterclockwise
- **Our goal is to control the flight trajectory** of a Parrot Mambo Minidrone (a small quadcopter that has MATLAB and Simulink support)
    - We have six quantities of interest (x, y, z, roll, pitch, and yaw)
    - But we only have four degrees of freedom (the four rotors speeds)

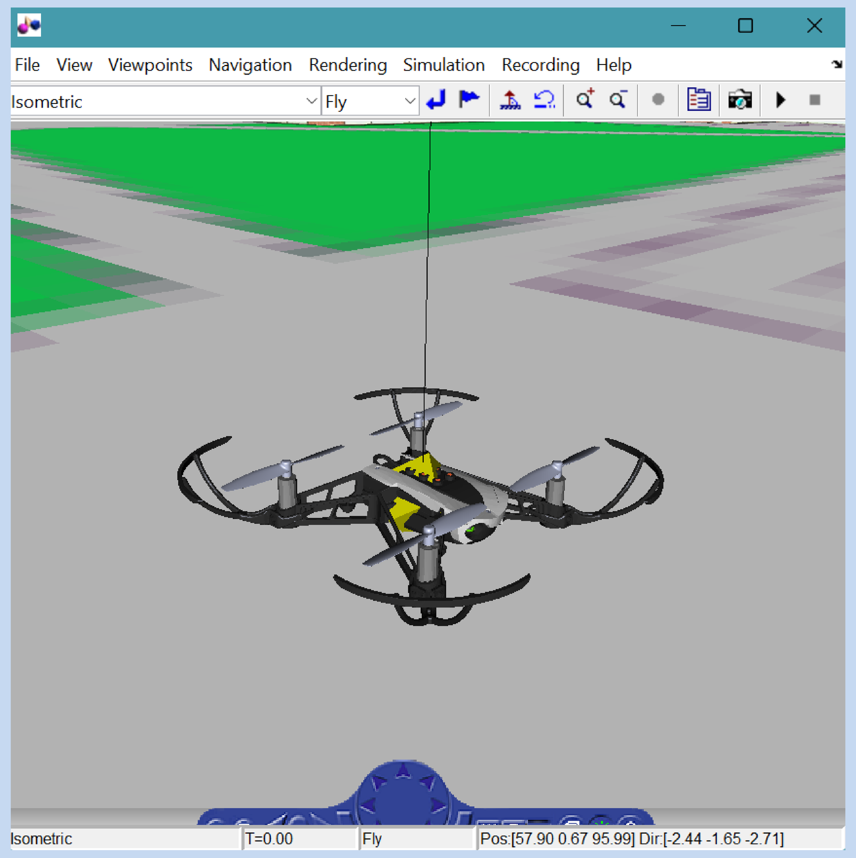


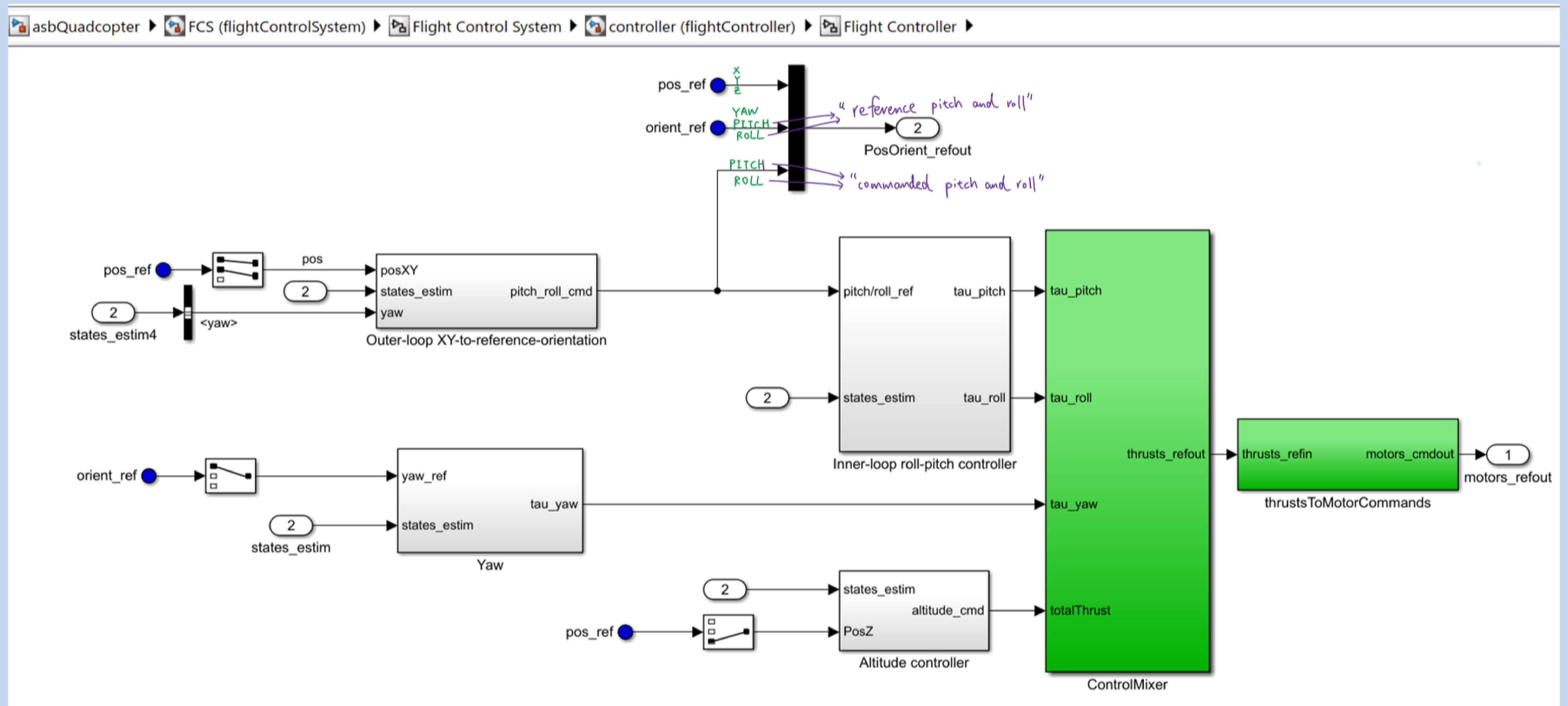


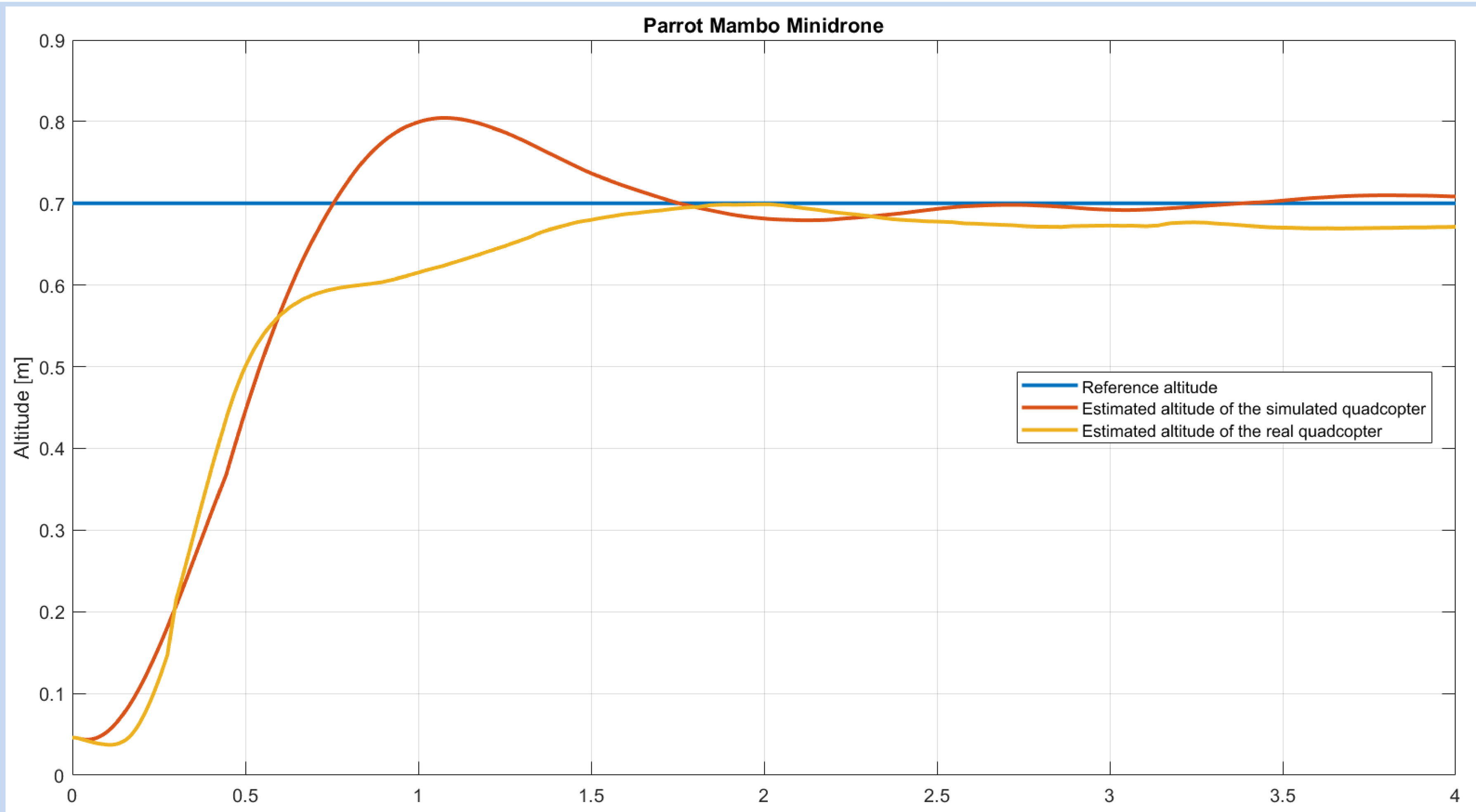


Methods

- We **model the flight dynamics** (from take-off to landing) of the quadcopter in a Simulink model
- We first take out the "outer-loop controllers" (the x and y controllers) and focus on **PID controlling** z, yaw, roll, and pitch
- Then we add the outer-loop controllers back and improve the x and y responses
- Finally, we **send the flight code from Simulink to the quadcopter via Bluetooth** and observe the agreement between simulated and actual performances







Results

- We **successfully applied control theories to the quadcopter in the simulated environment** to obtain very desirable performances
    - Settling times for z, yaw, roll, and pitch have all been reduced to less than a second
    - Steady-state errors for z, yaw, roll, and pitch have also been reduced to effectively zero
- However, **in practice, the quadcopter did not perform nearly as well**
    - Tuned controllers turned out to be way too aggressive for the quadcopter
    - Estimating the state values from the sensors turned out to be a huge challenge

Next steps

- We will continue to conduct flight tests to improve the quadcopter's performance as much as possible
- Then we will apply image-processing techniques to do more complicated maneuvers with the quadcopter
    - For example, we plan to implement object-detection and possibly object-following features

Acknowledgements

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