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1 Resources

- google drive folder

2 Problem Statement

Underactuated flying vehicle that is more cost and energy efficient.

3 Motivation

Modern Rocket uses 2 DOF revolute joint to turn the nozzle to control the thrust. Challenges are it has to resist a very high temperature and the joint need a large amount of energy to keep the nozzle in a specific direction. Instead, a precisely controlled off-center mass in the front of the rocket can create a torque that steers the Rocket.

3.1 TODO Add pictures to the slides – structure of modern Rocket, look more into how modern Rocket operates

4 Scope

In this project we will focus on the Mathematical Formulation and the design of controller. We will build on a working quadcopter where all 4 propellers will provide same constant thrust.

4.1 TODO Add quadcopter pics?

5 Detailed Context / Related work

5.1 TODO Draw a box diagram for our system

5.2 TODO Maybe look more into Piccolissimo and relate the two?

6 Tasks breakdown, potential challenges

1. Mathematical Formulation
    - Analysis of the system dynamic
    - How does a spinning mass create torque
    - How does the created torque affect the orientation of the system
    - The desired roll / pitch angle for system stability
    - The spinning mass dynamic
2. Pick our components
    - Hackable Quadcopter
    - A motor with pulse control that we can make the spinning mass stay longer in one direction

- What mass to attach? What arm to connect motor and mass?
- Mechanical device that enable us to mount our system on the Quadcopter: MAY NEED 3D PRINTING
- Microcontroller
- IMU for sensor measurements
- Wireless module for communication
- Battery

3. Simulation environment: maybe challenging because we working in 3D
    - Simulation in Matlab
    - State (orientation) estimation
    - How does motor inputs generate torque and in turn affect the orientation
    - Controller simulation
4. Hack the quadcopter
    - Be able to control the 4 propellers using our wireless module thru our microcontroller
5. Sensor Fusion
    - Configure the IMU, making use of accelerometer and gyroscope
    - Determine the rate of roll/pitch angle change
6. Control circuit for motor
    - make sure the motor is doing what it is supposed to before mounting it on quadcopter
    - Design a test to show that the off-center mass is leaning on one side
7. Putting it together
    - Integrate all our working components (wireless communication, motor pulse control, sensor fusion, simulation works)
    - Mount it on the quadcopter
8. Controller Design

- Real experimental results should be available since we already built our system and mount it on quadcopter
- controls the input to the motor and the propellers, by taking in state estimation and sensor measurements
- Responsible to achieve the desired roll/pitch angle to steer the vehicle
- Moreover, to stabilize the quadcopter from a moving position.

9. End-to-End testing
10. Documentation

6.1 TODO Put the above tasks breakdown in the slides? Each big topic (1,2,3) with one slide?

7 Project plan

Week	Milestone(s)	Demonstration
1	Pick our components	Reason choosing these parts
1-2	Hack the quadcopter	Controll the quadcopter with Arduino code
1-2	Mathematcial Formulation	Show our mathematical model
3	Sensor Fusion	Demonstrate angle change / vector graph
3-4	Control circuit for motor	Test: falling on desire side
3-4	Develop Matlab Simulation	Show simulation graph
5	Putting everything together	Show our modified quadcopter: video demo?
5-8	Controller Design	Show how quadcopter reacts with different controllers
9	End-to-end testing	Gather experimental results that supports our conclusion
10	Documentation	Document all our work

7.1 TODO Create a Gantt chart based on the above table

8 Expected Conclusion

We would like to conclude that a off center spinning mass is able to steer the quadcopter using the system's dynamic; and that such principle can be apply on Rocket for more effective way of stering a rocket.

8.1 TODO PUTIT ON THE SLIDE! I am bad with wording, maybe refine the above sentence a bit / any missing conclusion you guys want to draw?