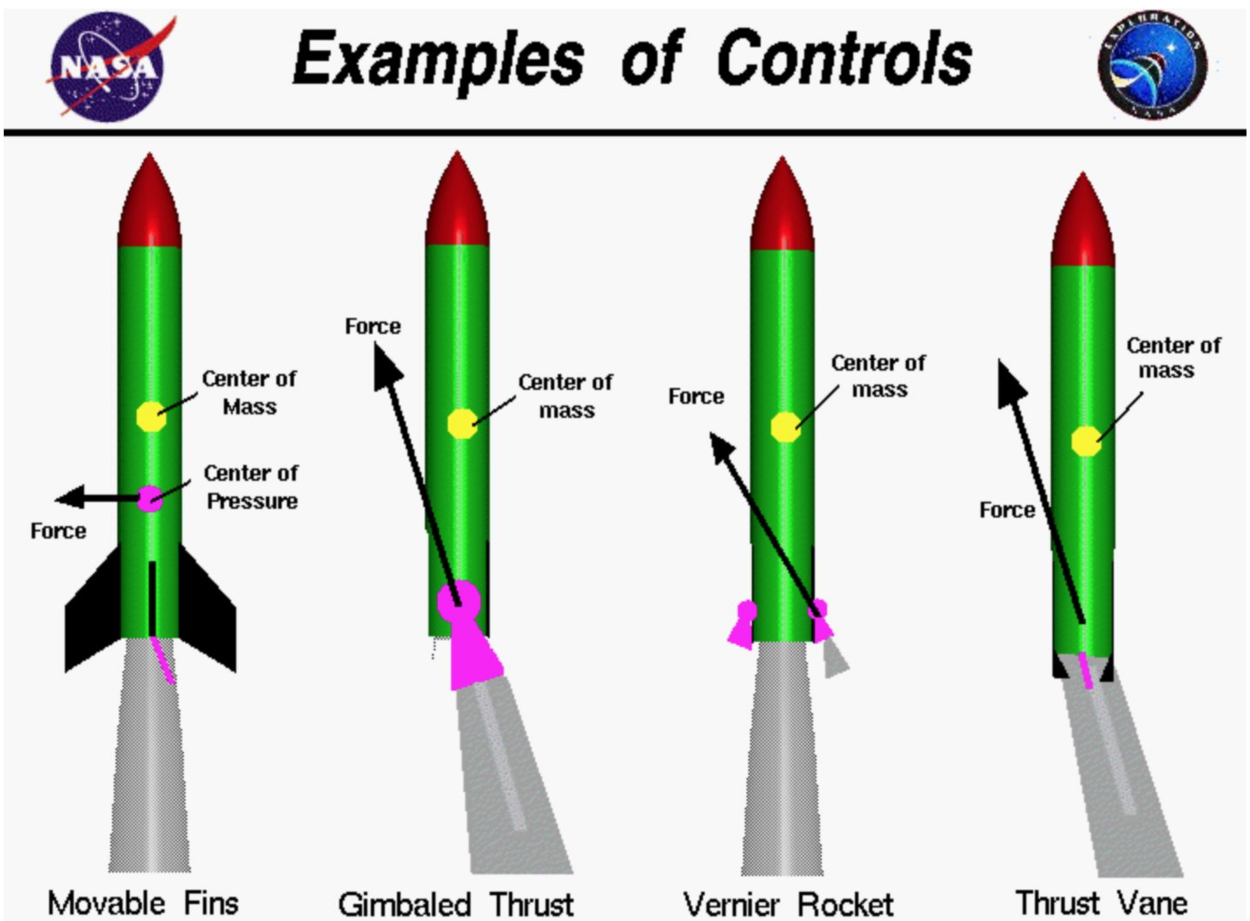
Big Picture

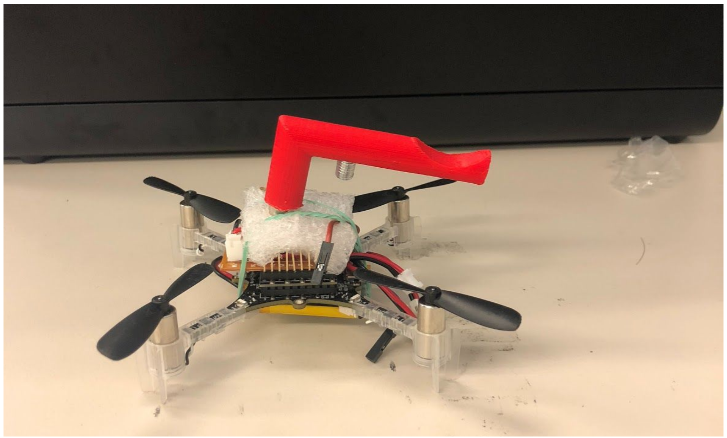
Modern Rocket uses 2 Degree of freedom revolute joint to turn nozzles to directly control the direction of thrust.

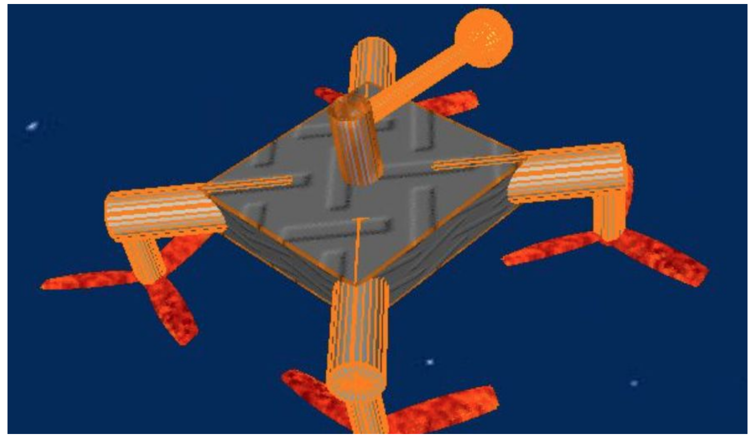
Challenges are the joint has to resist a very high temperature and also needs a large amount of energy to keep the nozzle in a specific direction. Instead, a precisely controlled off-center mass in the front of the rocket can create a torque that steers the Rocket.

Explore a new way to steer the rocket with underactuated controller is the general goal of our project. The approach aims for eliminating the massive controllers and being applicable to small rockets.



Specific project Scope





With the motivation from modern rocket control, we are using quadcopter with off center spinning mass to demonstrate this principle. Off center spinning mass controller would ideally replace the current rocket control system. The reason behind choosing quadcopter is both systems (rocket and quadcopter) have the same dynamic responses(under considered assumptions). Off center spinning mass would be underactuated control system and can be cost effective, more efficient, less computation involved solution. Omitting massive heavy rocket engines this approach can be beneficial for controlling small rockets as well.

Background

- *This research is the continuation of the capstone design project my team (Wilson Change, Lin Li, Angel Jimenez, Amir Omidfar)worked on for ten weeks in Spring 2018. Here is our final paper showing our progress by far:*

Related works

- *The dynamics of quadcopters has been already derived:*
  - *http://andrew.gibiansky.com/downloads/pdf/Quadcopter%20Dynamics,%20Simulation,%20and%20Control.pdf*
  - *http://andrew.gibiansky.com/downloads/pdf/Quadcopter%20Dynamics,%20Simulation,%20and%20Control.pdf*
- *However there are not much work done off-center spinning mass controller*
- *Related addressed problems :*
  - *https://penntoday.upenn.edu/spotlights/meet-piccolissimo-worlds-smallest-self-powered-controllable-flying-vehicle*
  - *https://uclalemur.com/blog/shuang-2017-spring-review*
- *Using prior related works we aim to attack this problem in three different sections simultaneously :*
  1. ***Mathematical Modeling:***
     Derive appropriate model expressing the dynamics of full system (quadcopter and spinning mass controller)
  2. ***Simulation:***
     Model the system in simulation environment and compare its behavior with Mathematical model
  3. ***Physical Implementation:***
     Build the prototype using Crazyflie 2.0 quadcopter implementing derived equations ideally. However we are also attempting opposite approach meaning start with physical prototype, passively stabilize the quadcopter, attach the controller and analyze its behaviour.