# Project Goal

To design a feedback controller of quadrotor drone. To simplify the model, the rotor and propeller properties will not be considered. Pulling force generated from propellers will be considered input. Moreover, wind effect will not be taken into consideration. Finally, only headless mode will be implemented in this model, where no yaw will be conducted by this drone.

# Model Definition

A diagram of a quadcopter

Description automatically generated

Figure The definition of axis and variables. Image from Douglas et. al. 2016.

A diagram of a drone

Description automatically generated

Figure Explanation how yaw generated in drone. Figure from Sabatino, 2015

Sabatino described the dynamics of the actuators as Equation 1, where is the total force generated; is the velocity of the propeller i; b is the ratio of pulling force generated based on angular velocity of propellers; d is the drag coefficient of propellers.

A math equations with numbers

Description automatically generated with medium confidence

Equation Actuator dynamics from 4 motors. Sabatino, 2015

To simplify this model, I select to use Headless mode of drone, where the direction of the drone is fixed. That is, no rotation along Z axis, which can be express as So the force in Equation 1 can be simplified as:

Equation Simplified Actuator dynamics from 4 motors given no Z axis rotation.

Also, to simply the model, wind effect is not considered in this report.

So the system dynamics can be simplified as follows, in Equation 3:

1. where **pink** line crossed variables are simplified because of .
2. where **green** line crossed variables are simplified because wind factors are not considered.
3. blue box indicates the input to the system.

A math equations on a white background

Description automatically generated

Equation The quadrotor system dynamics equation defined based on  
state variable that . Sabatino, 2015.  
 for cos(); for sin(); for tan().

To summarize, the simplified the overall dynamics of the headless drone system with no wind effect can be concluded as follows:

Equation The headless quadrotor dynamics summarized with no wind effect.

Define the states variables as, the input is defined as. Then the nonlinear state space system can be described as Equation 5:

Linearization

An equilibrium point is found by set :

From Eq 4.6,

From Eq 4.5,

From Eq 4.7,

From Eq 4.3,

From Eq 4.4,

Therefore, the equilibrium point is , where ,

and

The linearization can be calculated as follows:

At the equilibrium point, with the assumption that when is small, :

# Reference

Tesch, Douglas A., Diego Eckhard, and William Cechin Guarienti. "Pitch and roll control of a quadcopter using cascade iterative feedback tuning." *IFAC-PapersOnLine* 49.30 (2016): 30-35.

Sabatino, Francesco. "Quadrotor control: modeling, nonlinearcontrol design, and simulation." (2015).