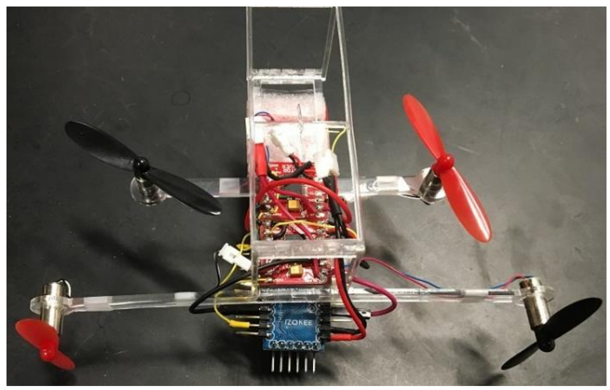
AAE421 Fall 2021 Project **Group Number____________**
Due on Dec 3rd, 2021 11:59 PM (EST)

The project will be conducted in groups. Please register in one of the teams via the following link by Nov 15th, 2021. Each team should have one team leader and seven to nine members.
https://docs.google.com/spreadsheets/d/14fzK1zttW2JHFnjBuJNzQ7FfYbb7J6P5mEE1qH_USEA/edit?usp=sharing

Vehicle Description

A lighter-than-air-robot (blimp) shown below has its longitudinal and lateral motion controlled by two sets of propellers, respectively.



The linearized longitudinal dynamics with respect to a reference condition at a constant altitude = 1 meter is represented by:

$$\frac{y_a(s)}{u_a(s)} = \frac{2.423s + 0.1097}{s^3 + 0.3537s^2 + 0.1394s + 0.002024}$$

where u_a, in range of 0 to 255, is the Pulse Width Modulation (PWM) command input for actuators and y_a in unit of mm is the altitude of the blimp. The lateral motion includes two modes, forward and rotation. The linearized rotational dynamics with respect to a reference condition at a constant heading angle = 0 degree is represented by:

$$\frac{y_h(s)}{u_h(s)} = \frac{0.00835s + .001745}{s^2 + 4.641 \times 10^{-5}s + 0.0002839}$$

where u_h, in range of -255 to 255, is the PWM command input for actuators. The negative input means the left motor is used while the positive input indicates that the right motor is used. y_h in unit of radian is the heading angle of the blimp. The linearized forward mode dynamics with respect to a reference condition at a constant forward speed = 0.3m/s is represented by:

$$\frac{y_f(s)}{u_f(s)} = \frac{0.0002557s^2 - 0.02031s + 0.05613}{s^3 + 0.4456s^2 + 27.55s + 4.316}$$

where u_f, in range of 0 to 255, is the PWM command input for actuators and y_f in unit of m/s is the forward speed of the blimp.

The pair of propellers controlling the vehicle's lateral motion can drive the vehicle in either rotational mode or forward mode, but not two modes simultaneously.

Written Section (70%) (submit the group project report before 11:59pm on Dec 3rd, 2021)

(a) Find the overshooting, settling time, and steady state error of the open loop system of the blimp longitudinal motion and two modes of the lateral motion, respectively, with step input.

(b) Sketch the root locus of the forward mode of the lateral motion with a proportional controller gain K_p>0.

(c) Design feedback controllers for longitudinal motion and two modes of the lateral motion, find the overshooting, settling time, and steady state error of the three closed-loop systems with step input.

(d) Simulate the closed-loop system output trajectory in Simulink when conducting the following tasks:

(i) altitude hold: specify a desired altitude and maintain the blimp at that altitude.

(ii) heading hold: in addition to task(i), specify a desired heading angle and maintain the blimp at that heading angle.

(ii) tracking a moving target doing circular motion with radius of 8 meters, speed of 0.3 m/s, and altitude of 1 meter. Calculate the accumulative distance error when following the object for one circle. Assume the blimp and the target start at the same point.

Presentation Section (30%)

(1) The presentation section is scheduled on Dec 6th. Control design and simulation results for the blimp need to be presented. The presentation include eight components:
    I. introduction,
    II. vehicle model description,
    III. open-loop system performance analysis,
    IV. controller design,
    V. closed-loop system performance analysis,
    VI. simulation results,
    VII. results analysis,
    VIII. summary.

(2) Each team member need to present at least one component listed above.

(3) Each group has maximum eight minutes to present and two minutes for questions.

(4) Presentation of each team will be judged by other teams.

(5) Team leader will be responsible for reporting the average judging scores collected from team members (a score sheet will be provided later).