MATLAB and Simulink Robotics Arena

Drone Modelling, Perception and Control

Introduction to Drones and Simulink

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Upcoming Webinars

Drone Modeling, Perception and Control using MATLAB and Simulink

Timeline

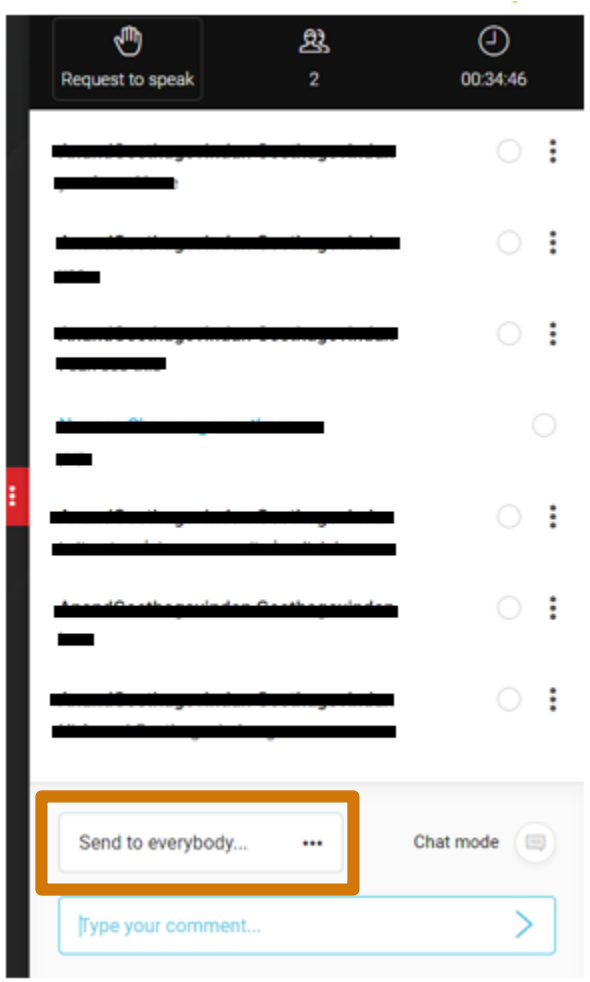
Sl.no	Webinar Name	Date	Time	
1.	Introduction to Drones and Simulink	Tuesday, 20-Oct-2020	5.00 PM to 6.00 PM	Register Now
2.	Controls and Deployment to Hardware	Tuesday, 27-Oct-2020	5.00 PM to 6.00 PM	Register Now
3.	Planning Flight States	Tuesday, 3-Nov-2020	5.00 PM to 6.00 PM	Register Now
4.	Perception	Tuesday, 10-Nov-2020	5.00 PM to 6.00 PM	Register Now

During the Webinar

Questions in Chat

Send to everybody

Poll Questions



During the Webinar

- Requirement:
  - Complete MATLAB Onramp

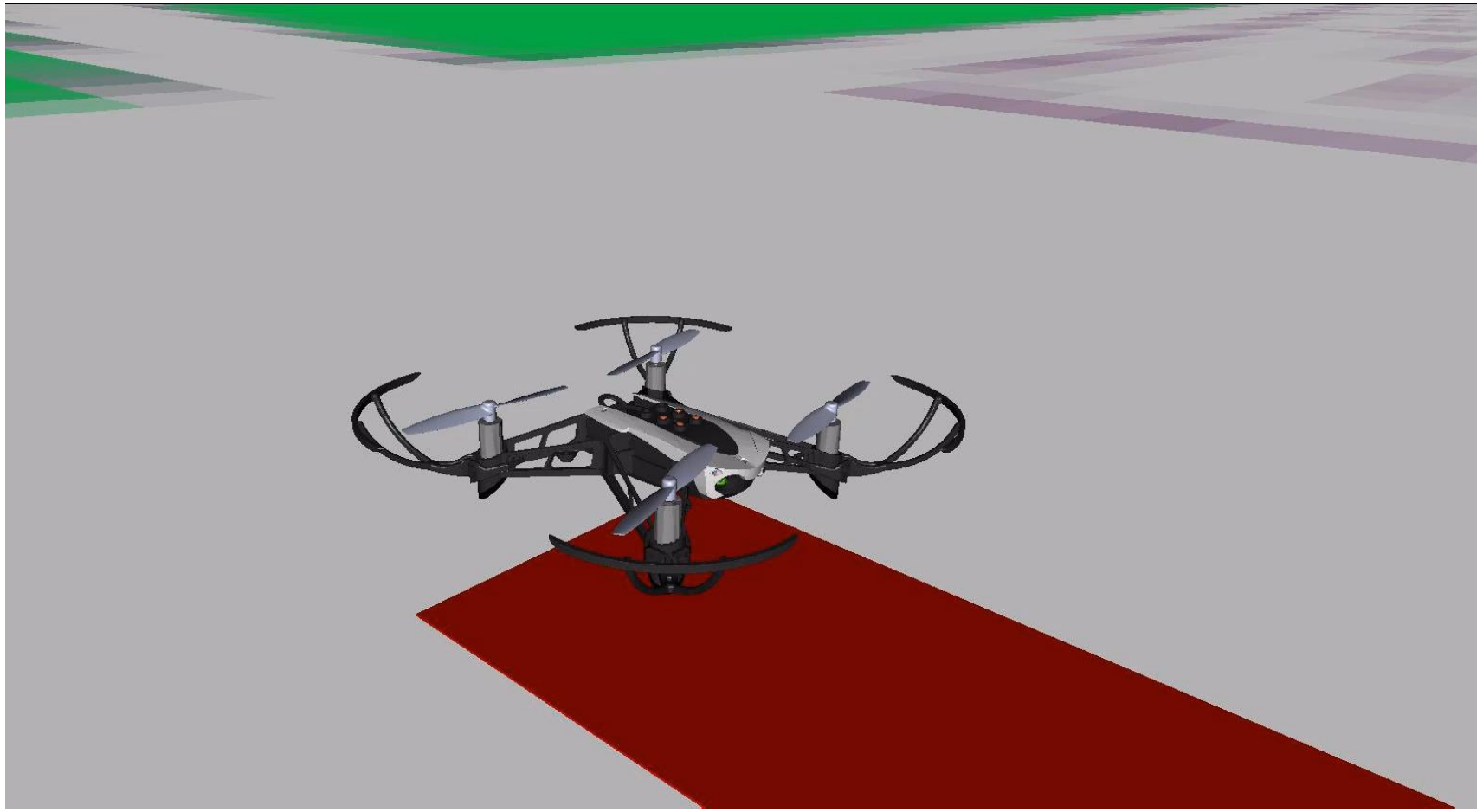
- ~45 minutes and open to questions

- For more questions:

  minidronecompetition@mathworks.com

  facebook.com/groups/RoboticsArena/

What will we try achieve by the end of the webinar series?



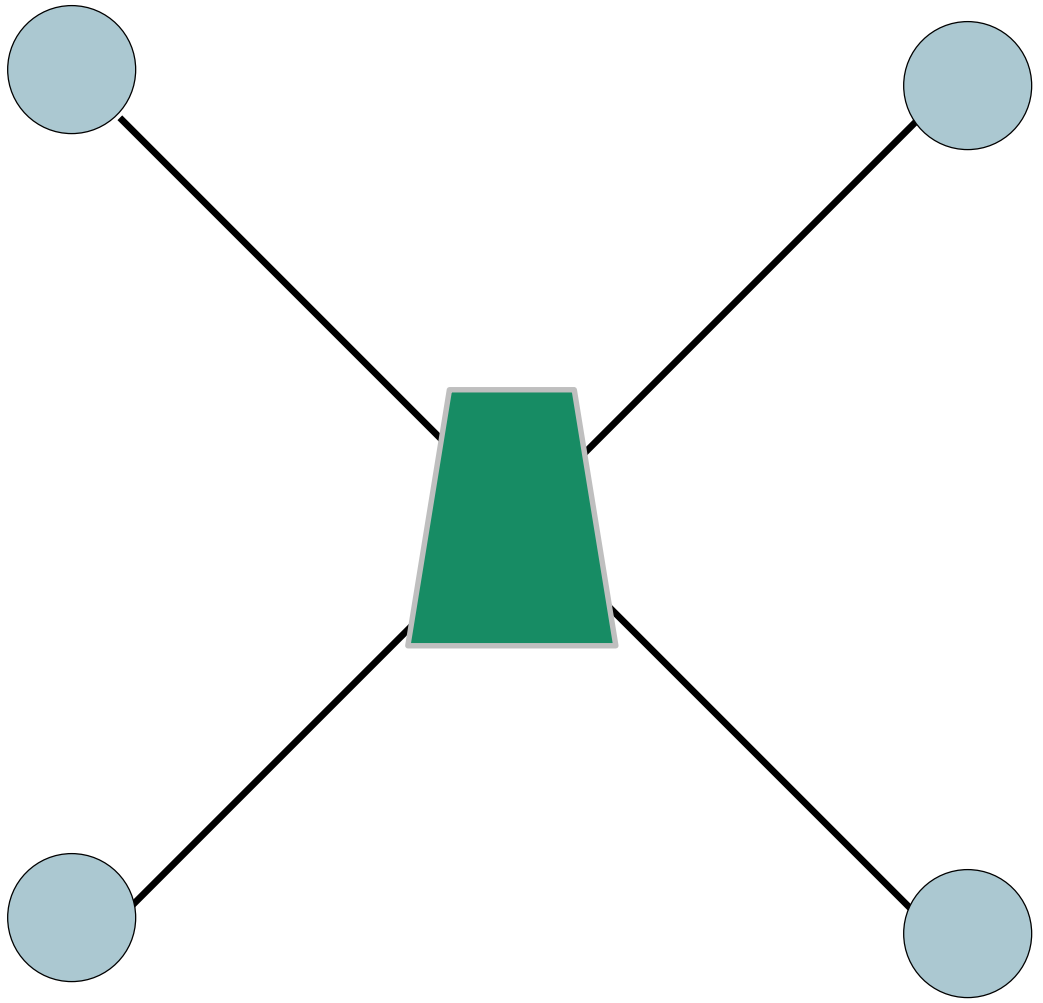
Agenda

- What is a drone/quadcopter?
- Drone degrees of freedom
- Understanding the model of a drone
- Introduction to Simulink
- Summary of the upcoming webinars

[Poll Question]
Have you used drones before?

What is a quadcopter?

- Rotating wing aircraft (rotorcraft)
- 4 rotating propellers
- Rotors used to generate lift



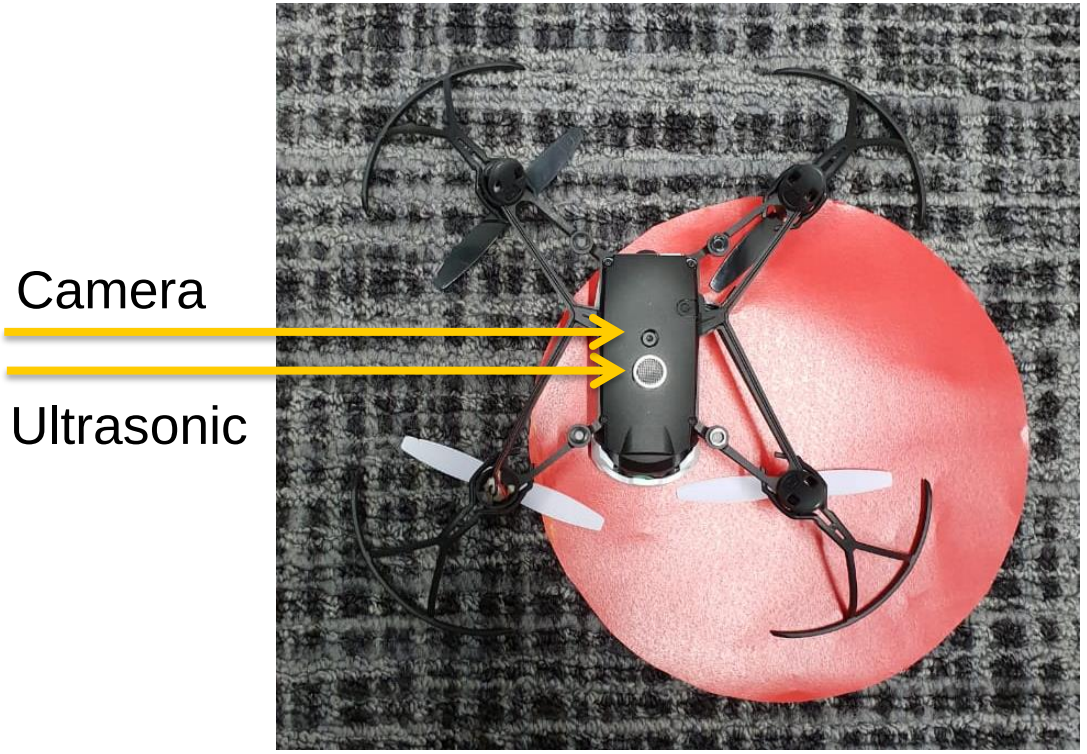

Control
Perceive
Implement
Plan

Knowing the system

- Work with the already available hardware
  - Parrot Mambo Minidrone
- Sensors
- Actuators
  - 4 motors each with its propeller

Sensors

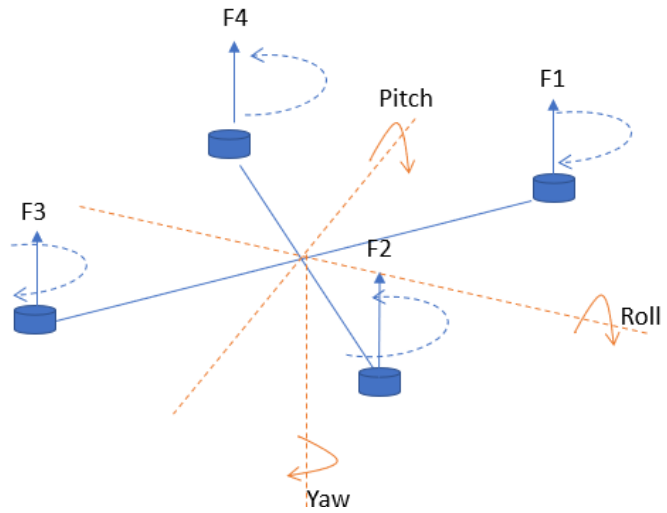
- Ultrasonic Sensor
  - To calculate altitude
- Camera
  - To capture the view
  - To calculate horizontal velocities
- Pressure Sensor
  - To calculate altitude
- Inertial Measurement Unit (IMU)
  - 3-axis accelerometer
  - 3-axis gyroscope



Actuators

- 4 motors
- Provide motor commands
  - Command drone to move in specific directions
  - Decide which motor to send command to and what value to send
- Configuration:
  - X configuration
  - + configuration

Equations of motion



- Work on the concept of balancing forces and torques
- Translational Dynamics:

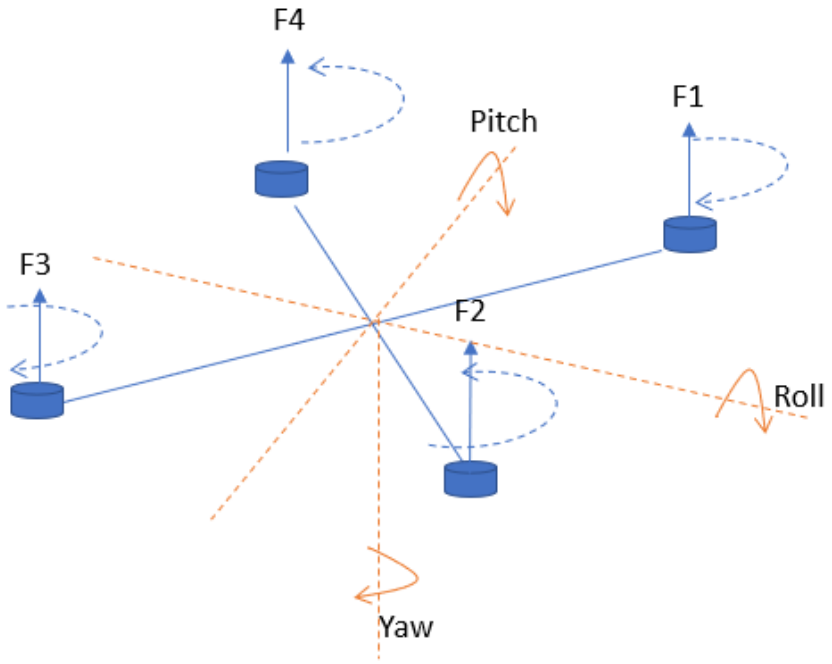
$$F_{frame} = F_{gravity} - F_{thrust} - F_{drag}$$

- Rotational Dynamics:

$$\tau_{frame} = \tau_{motors} - \tau_{gyro} - \tau_{inertia}$$

Drone motions

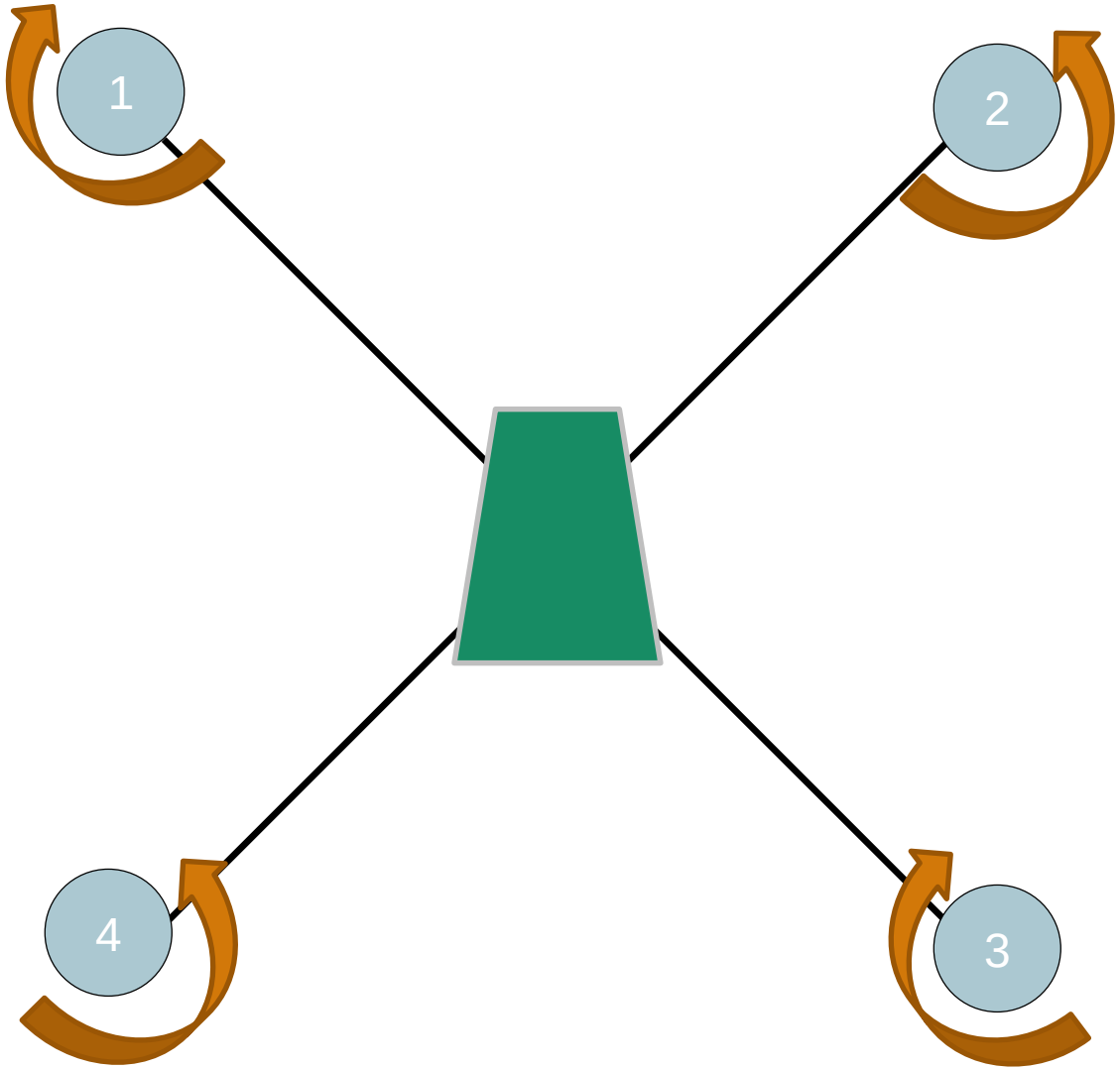
- 6 degrees of freedom
  1. Up-down
  2. Left-right
  3. Forward-backward
  4. Rotation around X-axis: Roll
  5. Rotation around Y-axis: Pitch
  6. Rotation around Z-axis: Yaw



- What we will control?
  - Thrust, Pitch, Roll, Yaw

How do we control the drone the motion?

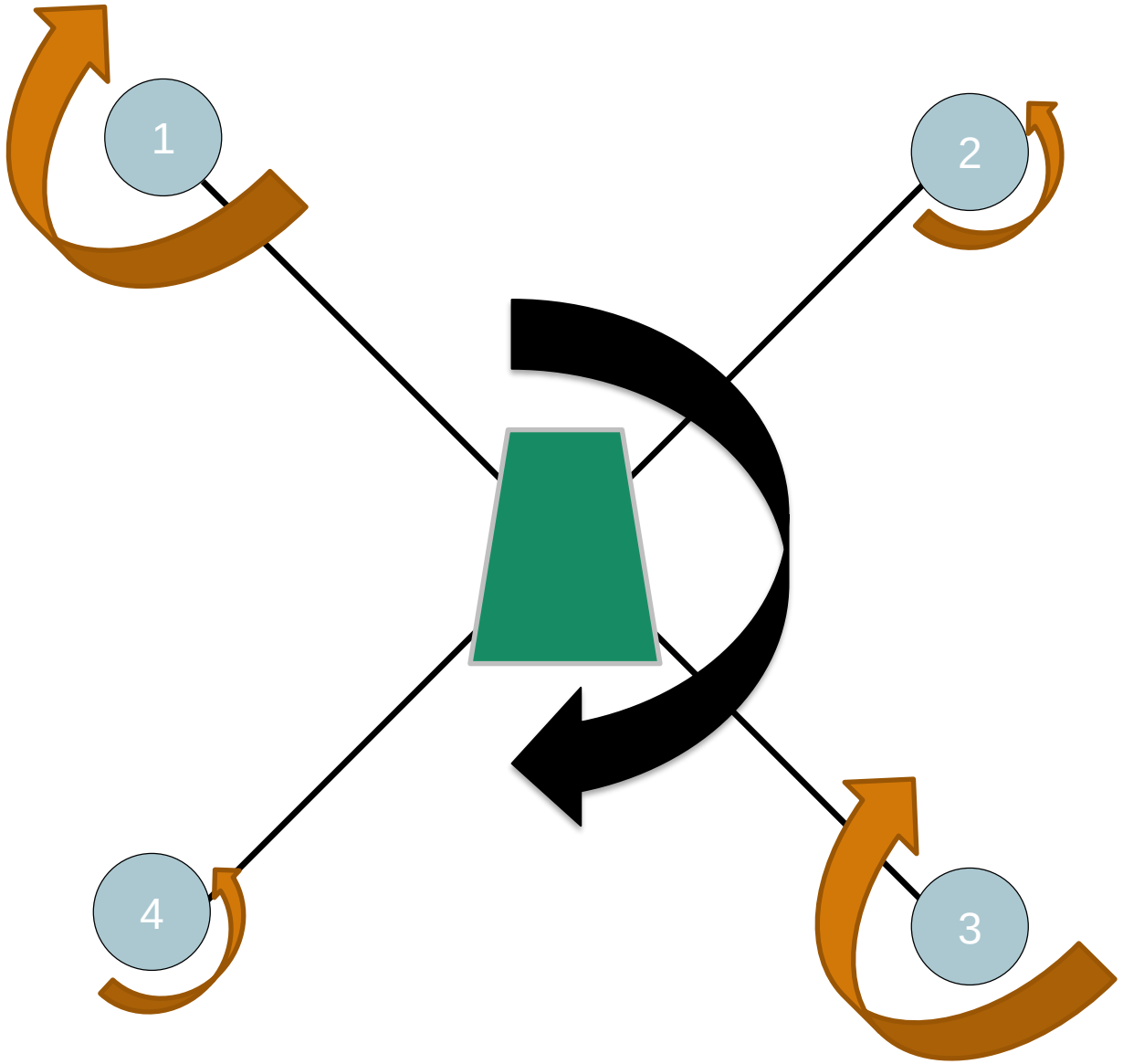
Thrust



Motor arrows indicate motor torque direction

How do we control the drone the motion?

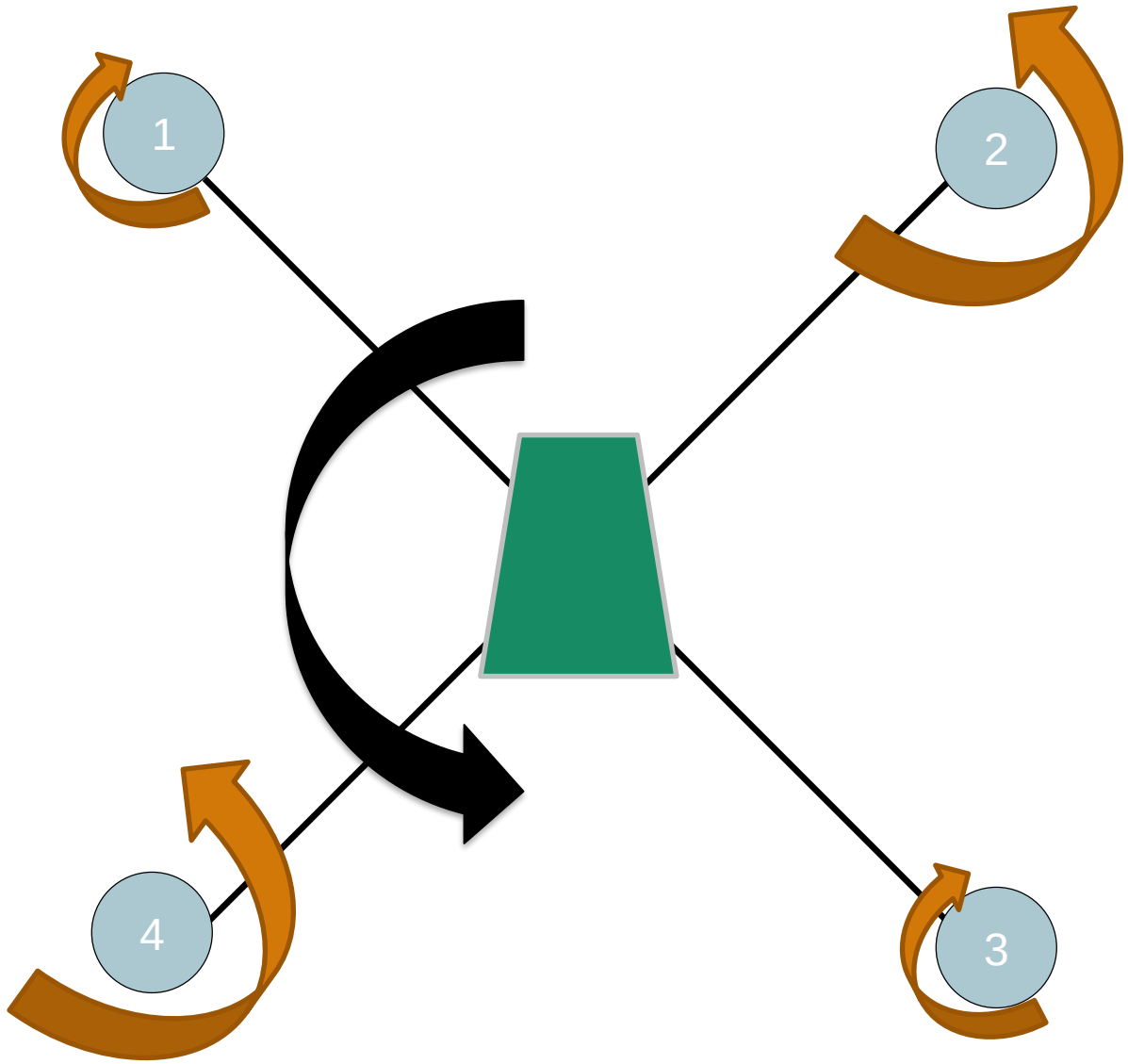
Yaw



Motor arrows indicate motor torque direction

How do we control the drone the motion?

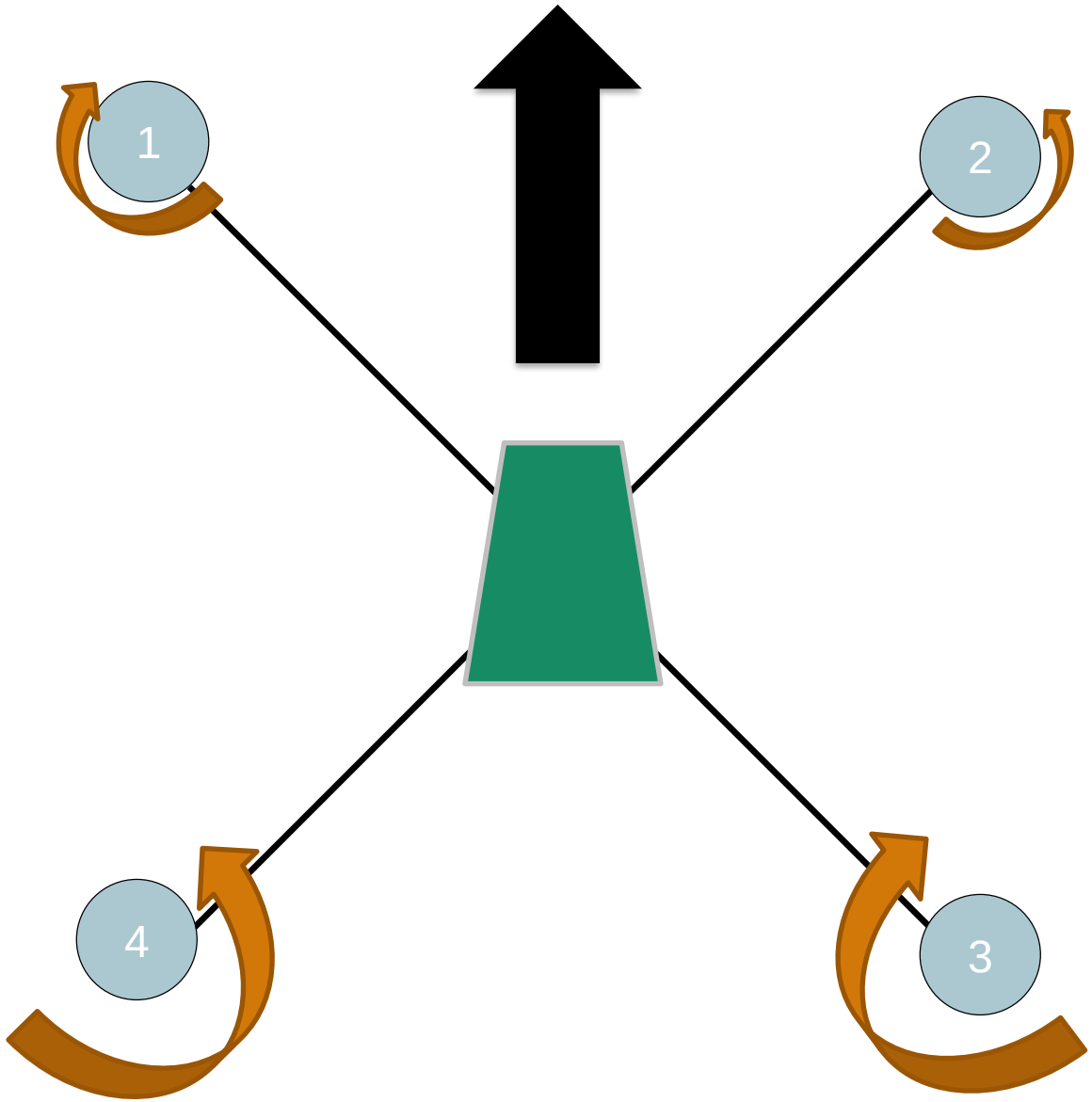
Yaw



Motor arrows indicate motor torque direction

How do we control the drone the motion?

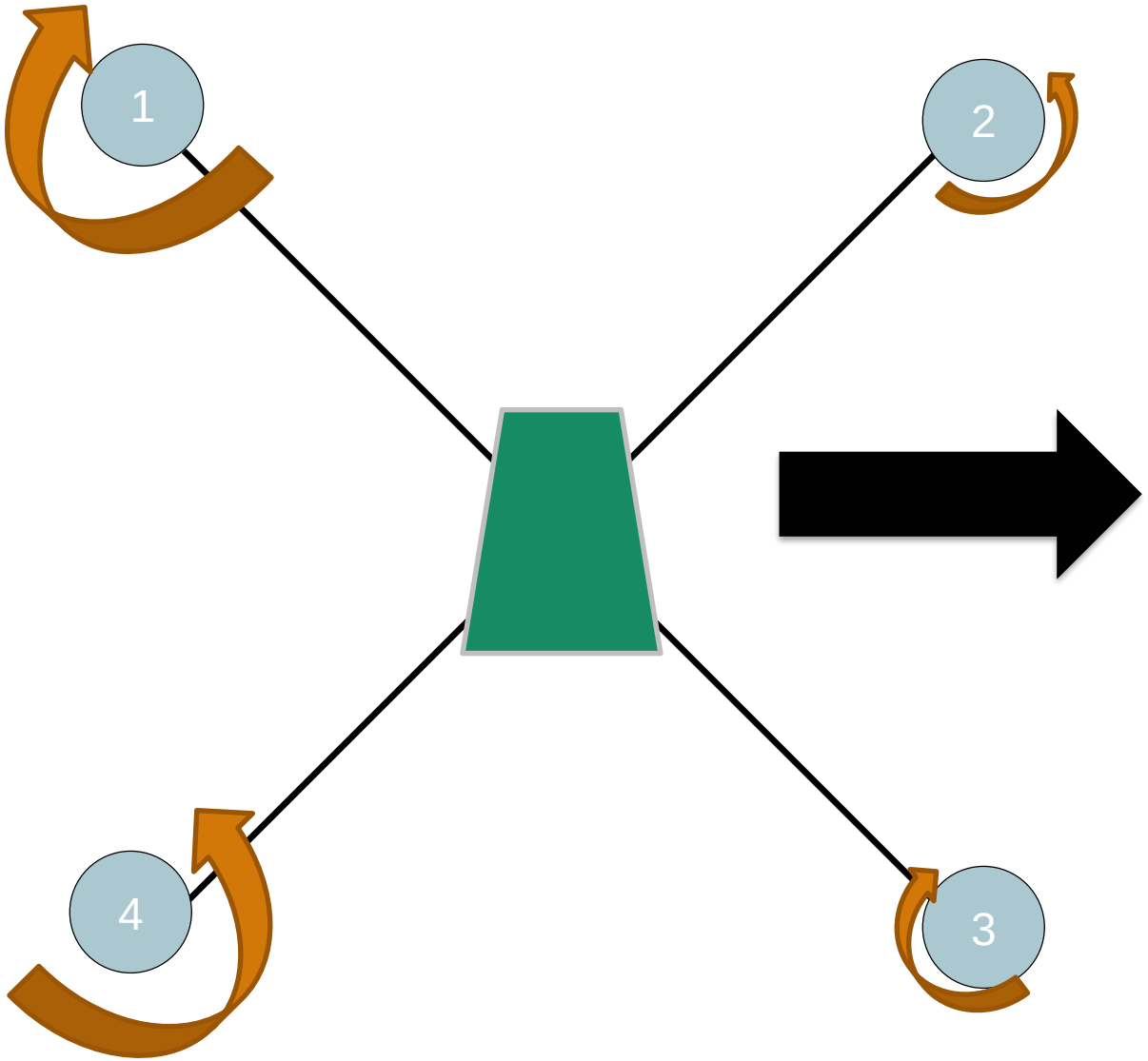
Pitch



Motor arrows indicate motor torque direction

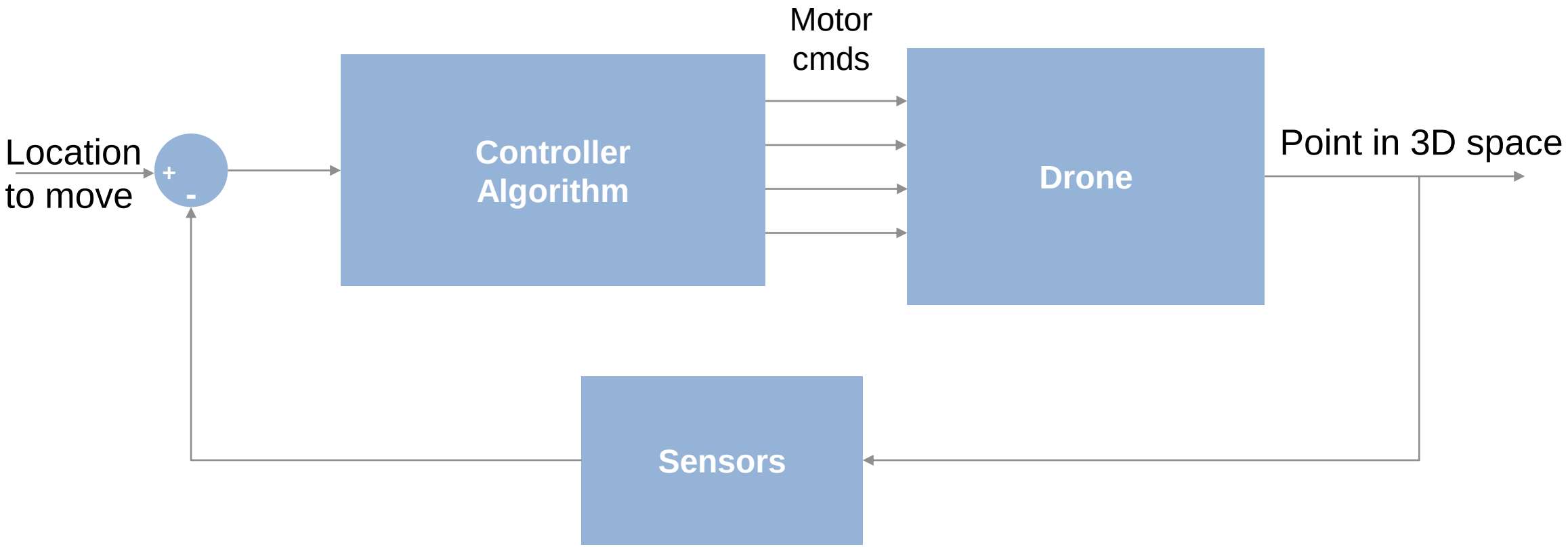
How do we control the drone the motion?

Roll

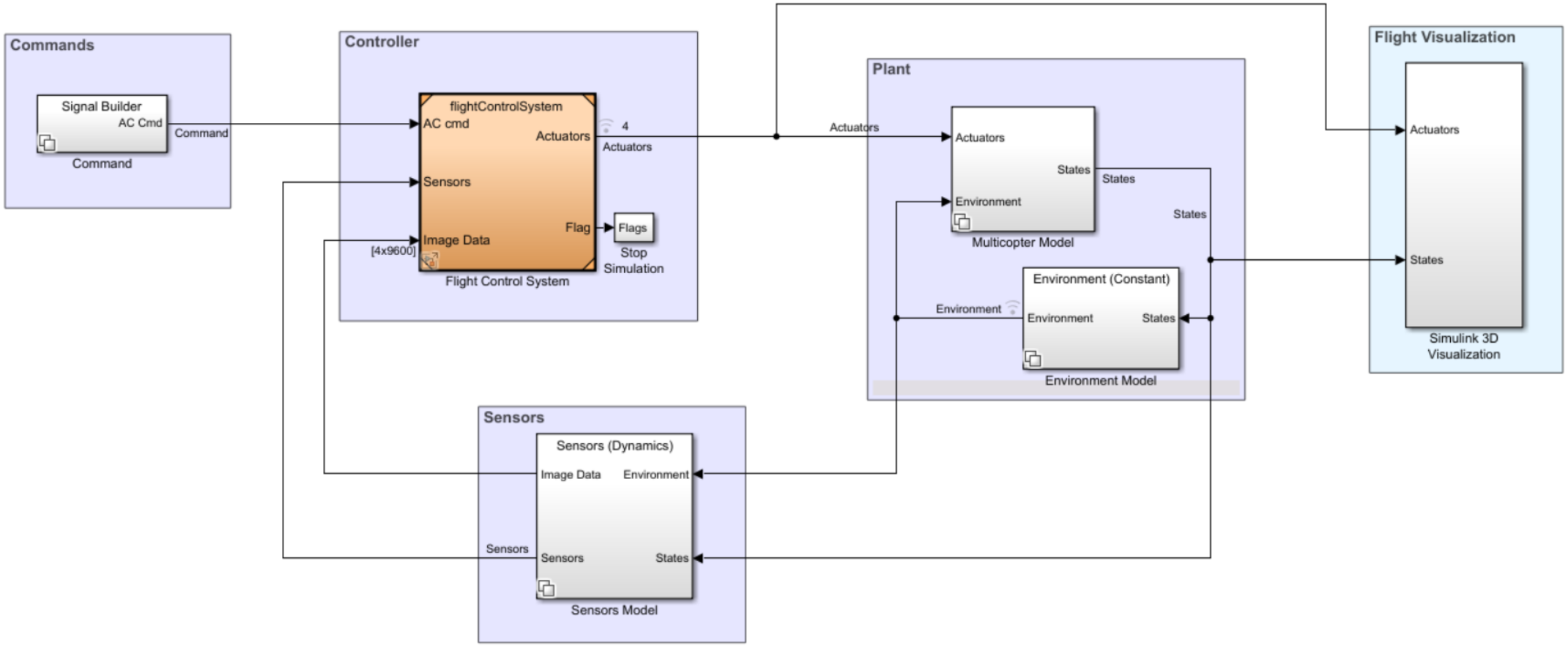


Motor arrows indicate motor torque direction

Modelling a drone

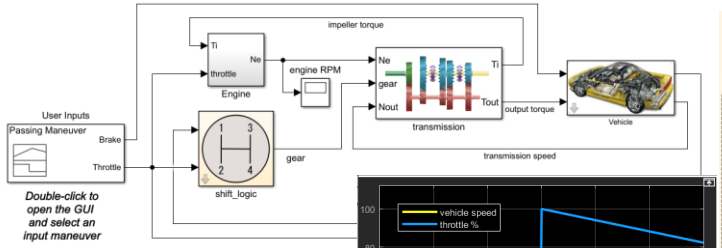


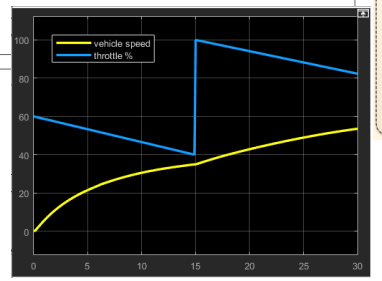
Modelling a drone

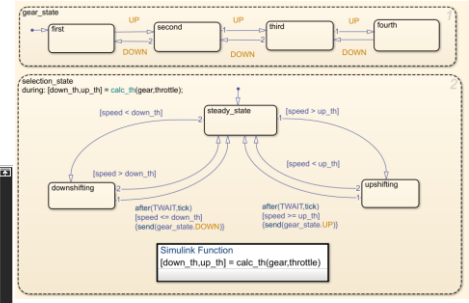


SIMULINK®

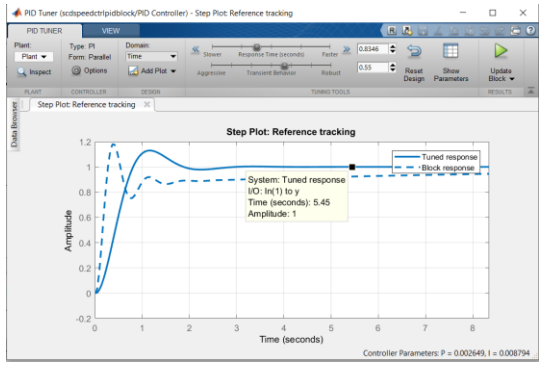
Modeling, simulation, and embedded systems

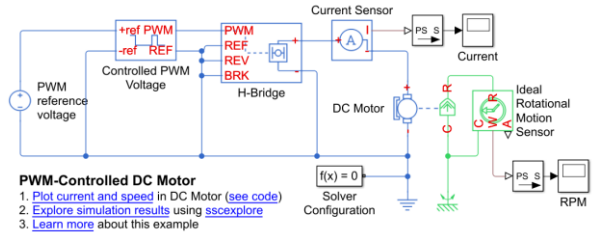


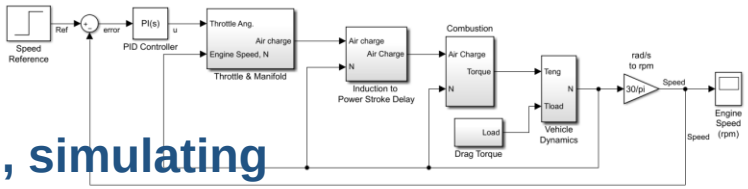


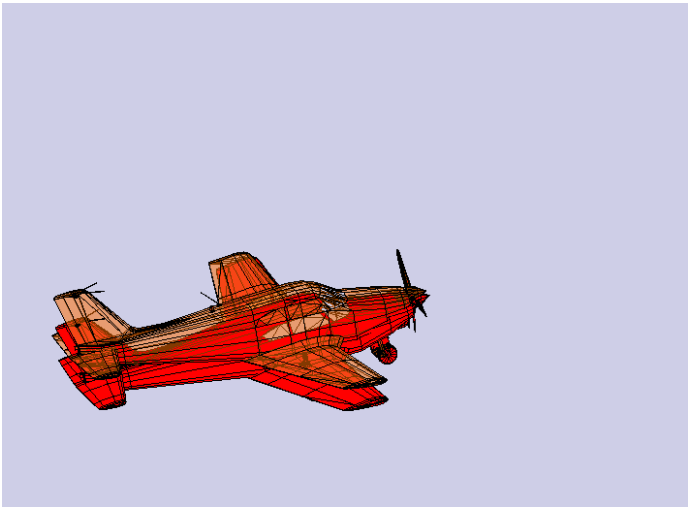


- Platform for **Model-Based Design**
  - **Block diagram** modeling
  - **Simulation** of physical systems
  - Automatic **code generation**
- **Applications** in:
  - Control systems
  - Signal processing
  - Communications systems









The leading environment for modeling, simulating and implementing dynamic and embedded systems

MATLAB and Simulink Robotics Arena

MATLAB and Simulink for Aerospace System Design

"Model-Based Design gave us advanced visibility into the functional design of the system. We also completed requirements validation earlier than was previously possible and simulated multiple simultaneous component failures, so we know what will happen and have confidence that the control logic will manage it. On earlier projects, it took up to nine months to integrate our fuel system design with the simulated cockpit, or iron bird. Using Model-Based Design on the A380, it took less than a month, Similarly, by reusing the model to commission the HIL rig, we saved three months of development and shortened the time from initial concept to first flight."

Christopher Slack,

Airbus

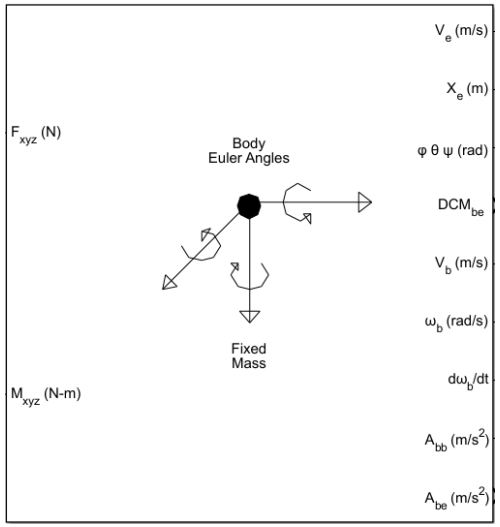
The Airbus A380.

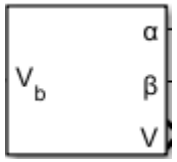
Using Simulink Blocks

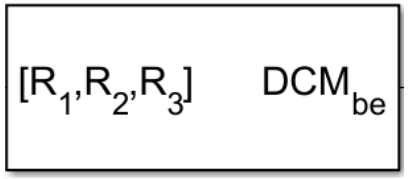
Aerospace Blockset

- 6-DOF block to integrate the forces in moments in all directions which avoids the need to code complex mathematical equations

- Rotation blocks and Coordinate transformation blocks





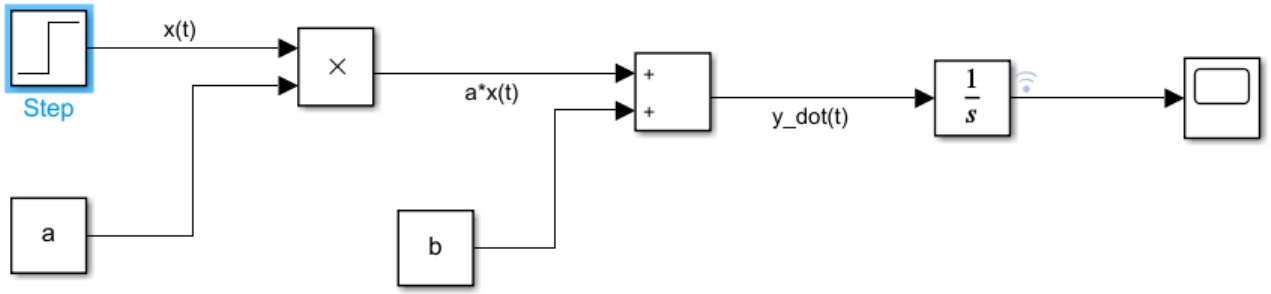


[Poll Question]
Have you used Simulink before?

[Modeling a differential equation]

$$\dot{y}(t) = ax(t) + b$$

$$y(t) = \int (ax(t) + b)dt$$

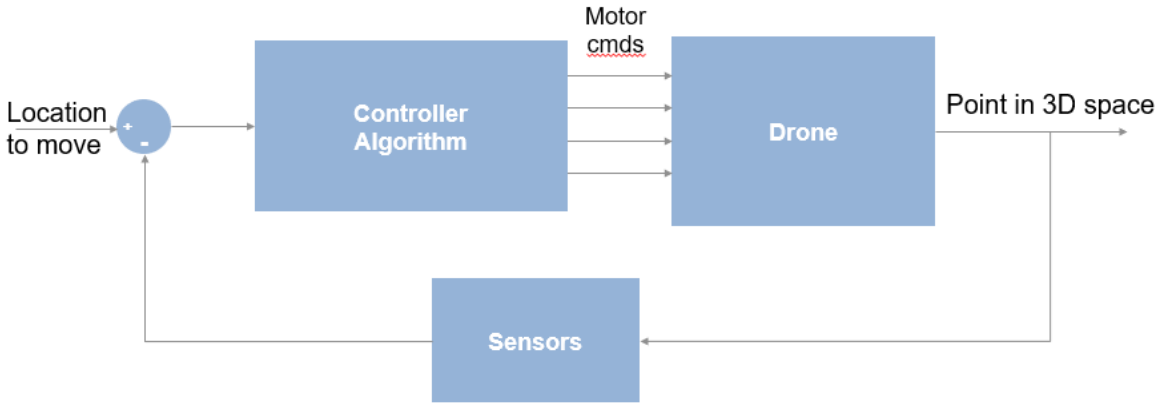


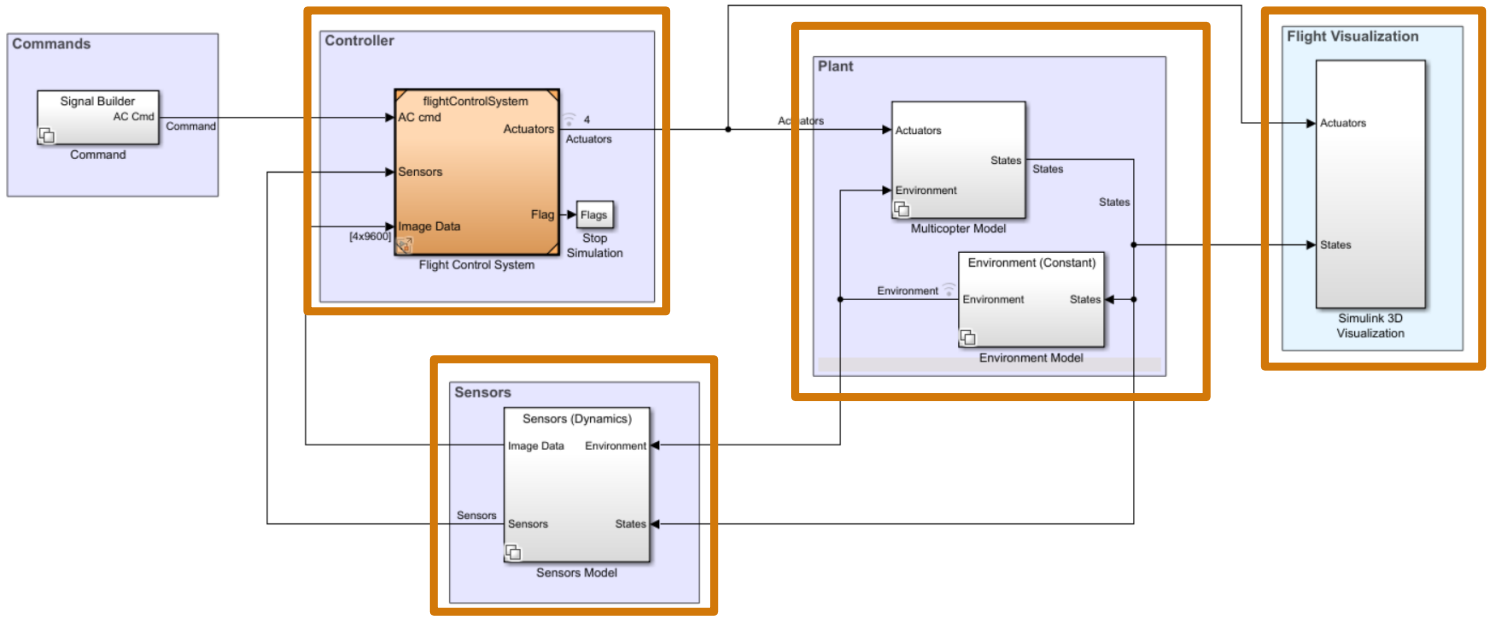
[Parrot Minidrone Competition Model]

Using Simulink Blocks

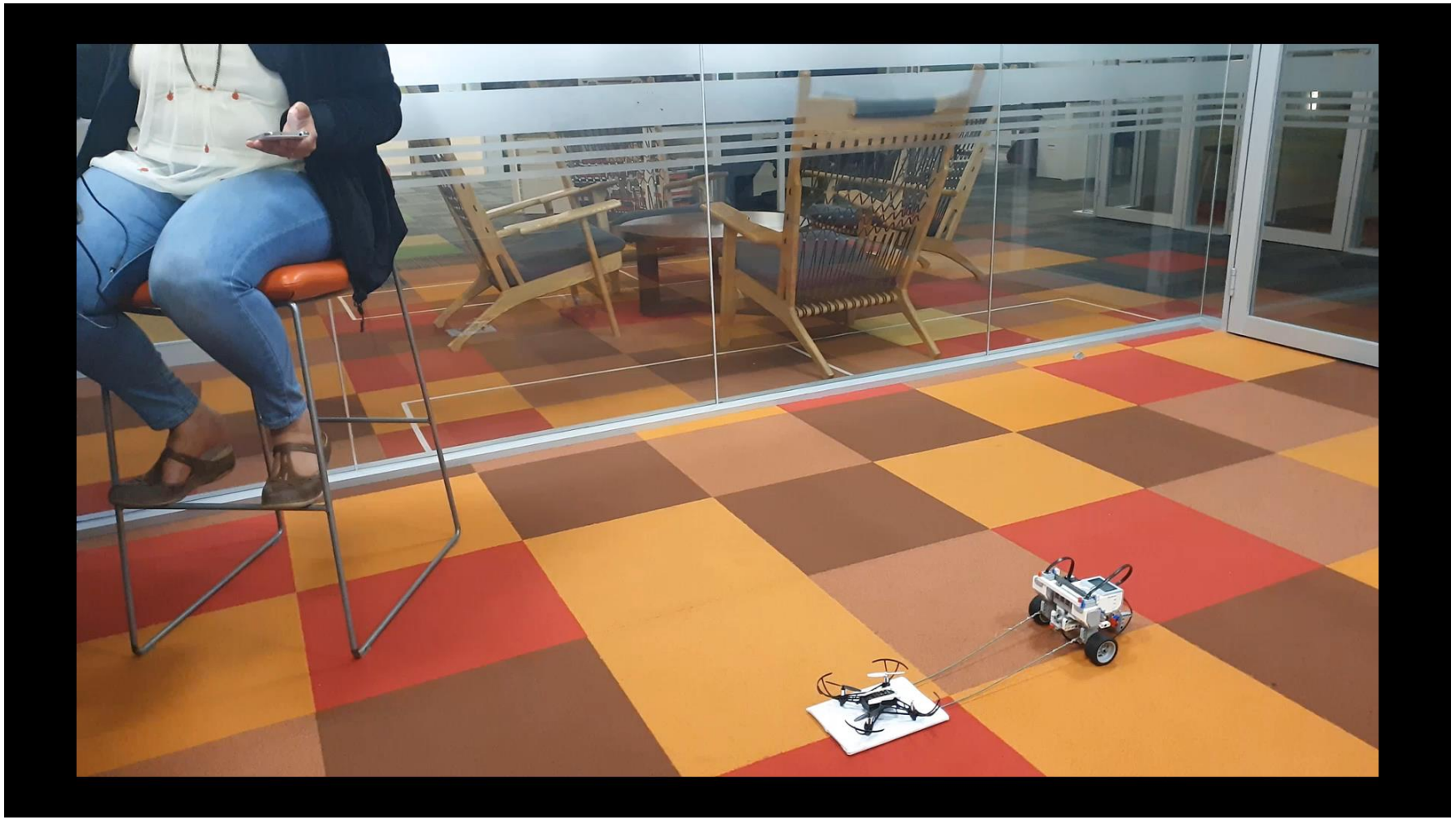
What do we have in the model?

- Model of a Parrot Mambo Minidrone
  - Plant
  - Sensors
- Visualization environment
- Design of a controller that hovers a drone





LEGO + Parrot Minidrone + Android

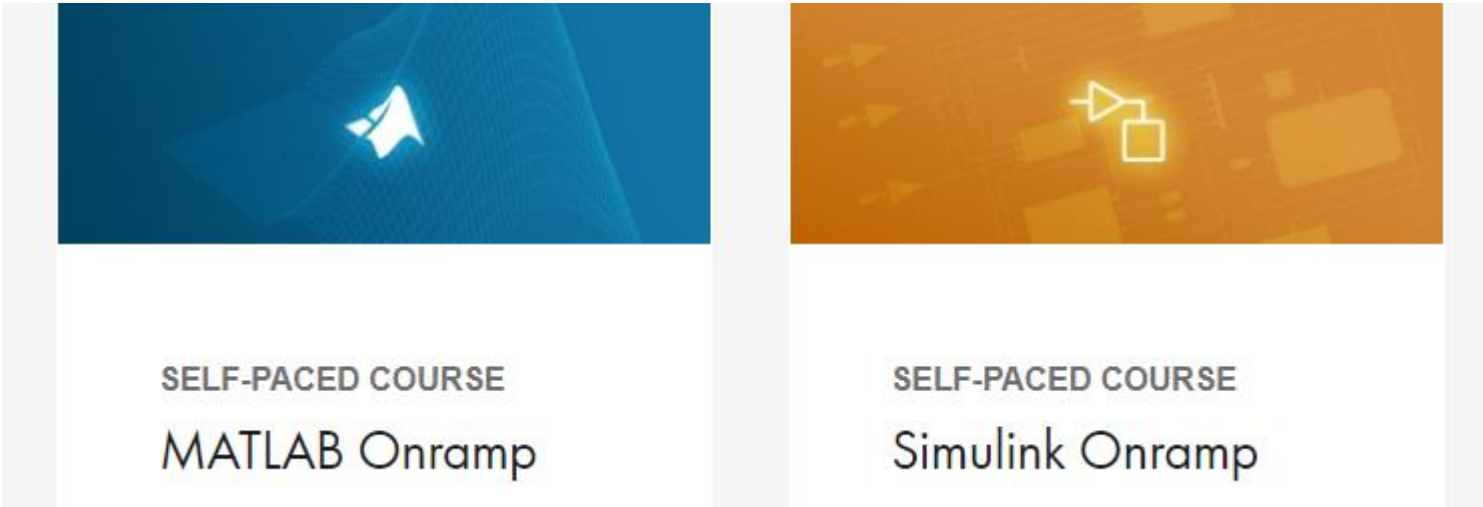


[Poll Question]
Would you want to learn more about Simulink?

Recommendations for Upcoming Webinar

- Complete Simulink Onramp
  - To emphasize on what we learnt today

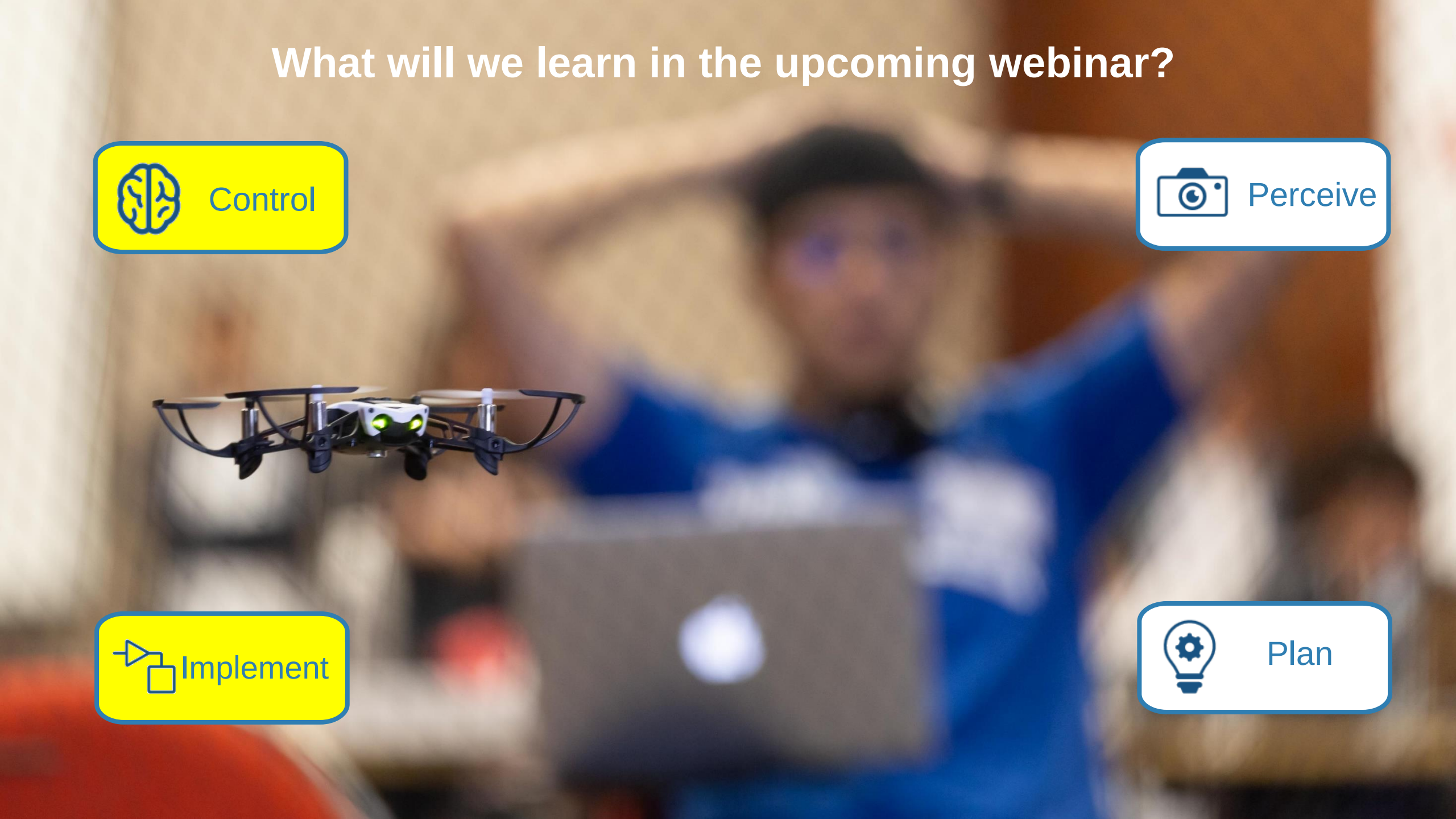
- See the video 1 on Drone Simulation and Control



How to access the Onramps?

- Check if your institute has Campus Wide License:
  - https://www.mathworks.com/academia/tah-support-program/eligibility.html
- Request for Trial:
  - https://www.mathworks.com/campaigns/products/trials.html

What will we learn in the upcoming webinar?



Resources

Robotics Arena

- **Contact us**

   minidronecompetition@mathworks.com

   facebook.com/groups/RoboticsArena/

- **Student Videos and Tutorials**
  mathworks.com/academia/student-competitions/tutorials-videos.html
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- **Racing Lounge blog:**
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Before Next Lesson!

- Complete Simulink Onramp
- See video 1 on Drone Simulation and Control