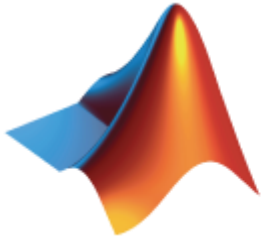


MATLAB and Simulink Robotics Arena

Drone Modeling, Perception and Control

Control Systems and Deployment on Hardware

Maitreyee Mordekar, *MathWorks*
https://www.linkedin.com/in/mordekarmaitreyee/

Upcoming Webinars

Drone Modeling, Perception and Control using MATLAB and Simulink

Timeline

Sl.no	Webinar Name	Date	Time	
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

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

- ~45 minutes and open to questions

- For more questions:

minidronecompetition@mathworks.com
facebook.com/groups/RoboticsArena/

Control

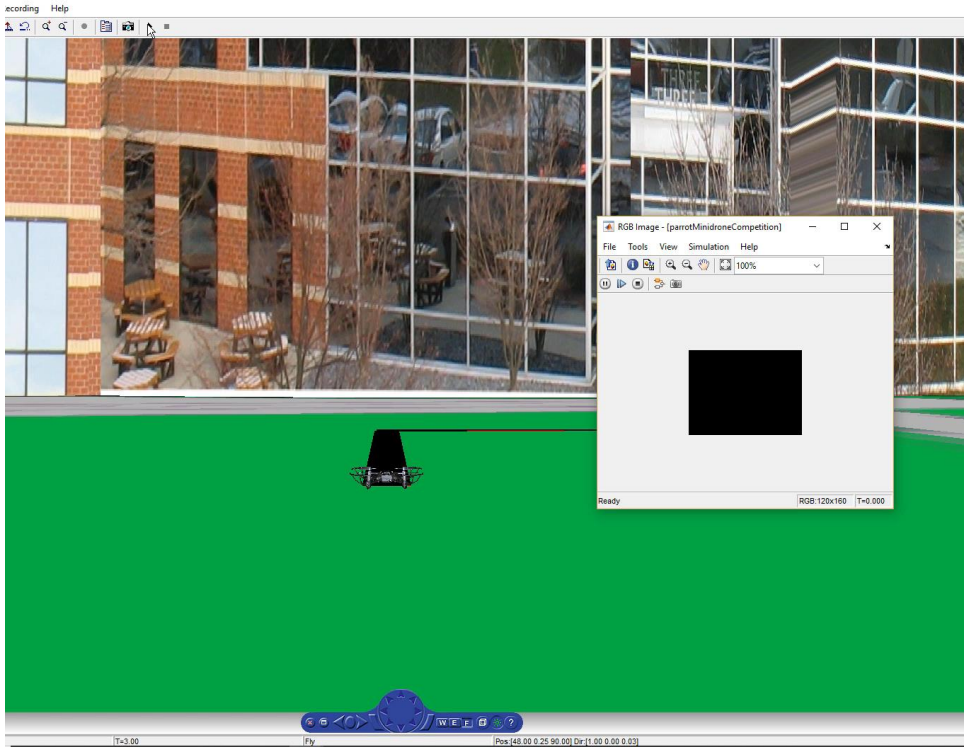
Perceive

- **Complete MATLAB Onramp**
- **Complete Simulink Onramp**
- **See video on Drone Simulation and Control**

Implement

Plan

What we will learn by the end of this session?

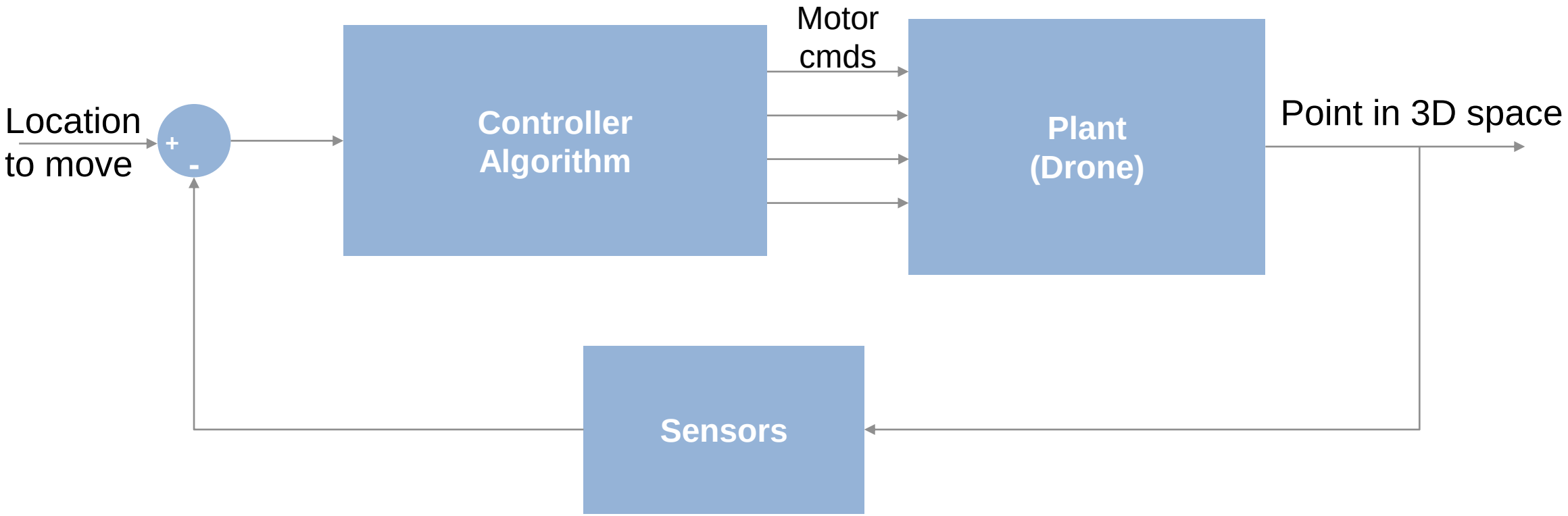


Agenda

- Modelling a drone using Simulink
- Walkthrough the Simulink model
- Low level controls of a drone
- Code generation from Simulink model
- Deployment on hardware
- Summary

Recap

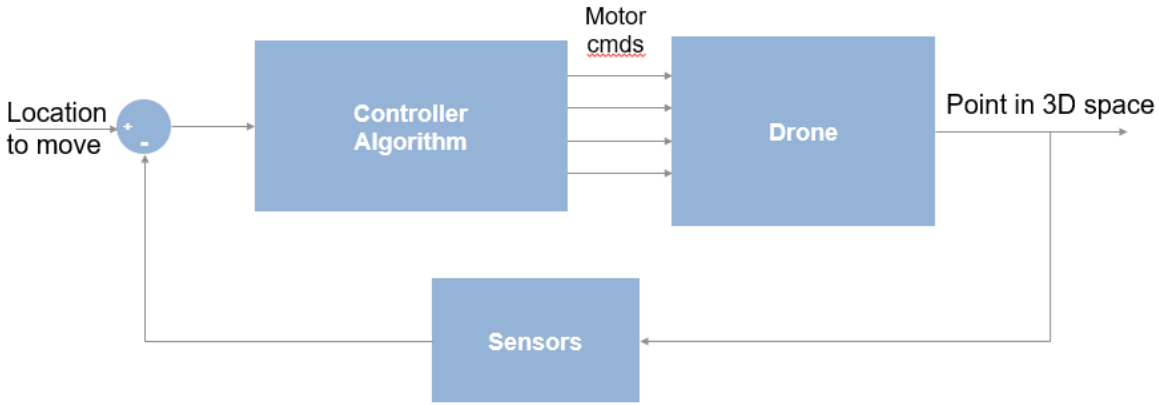
Modeling a drone

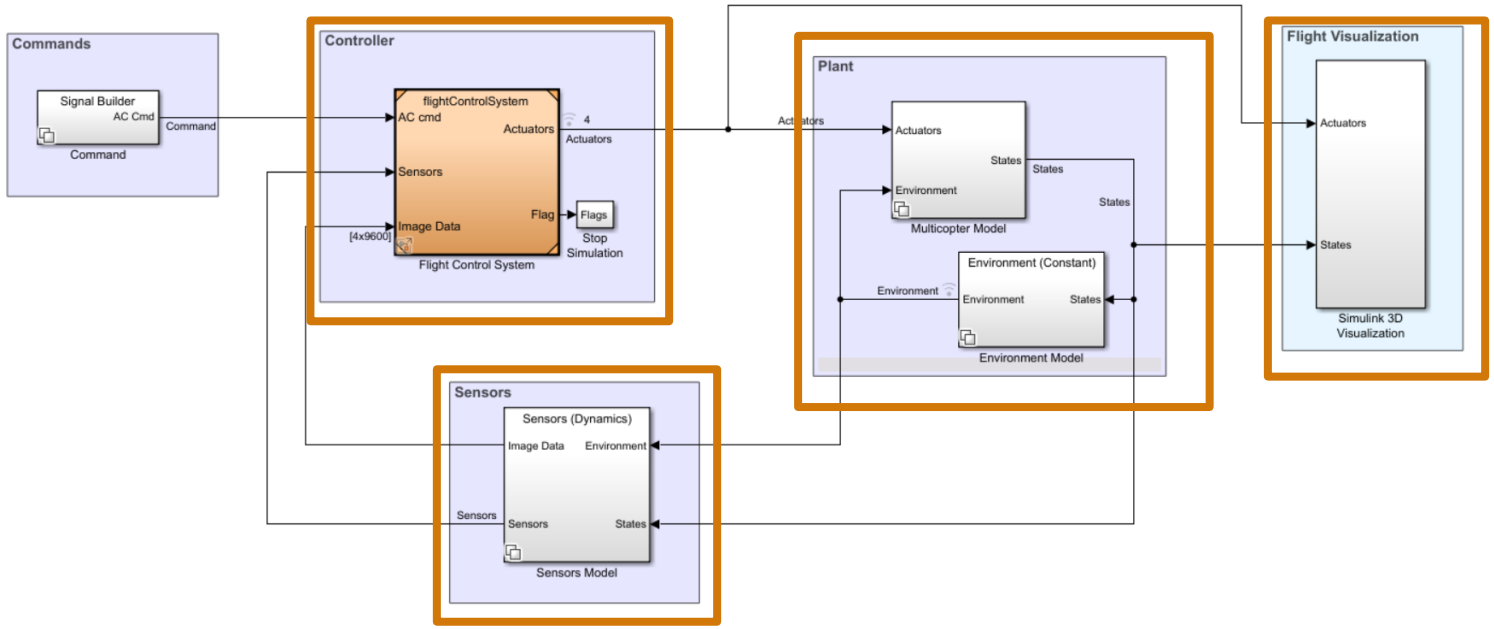


Recap

Modelling a drone using Simulink

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



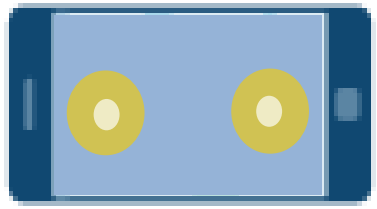


Controlling a drone

Manual control

Parameters controlled independently:

1. Altitude
2. Pitch
3. Roll
4. Yaw

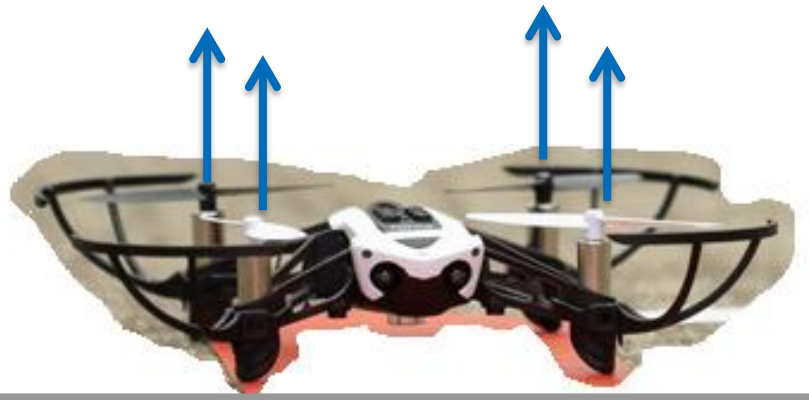


Commands

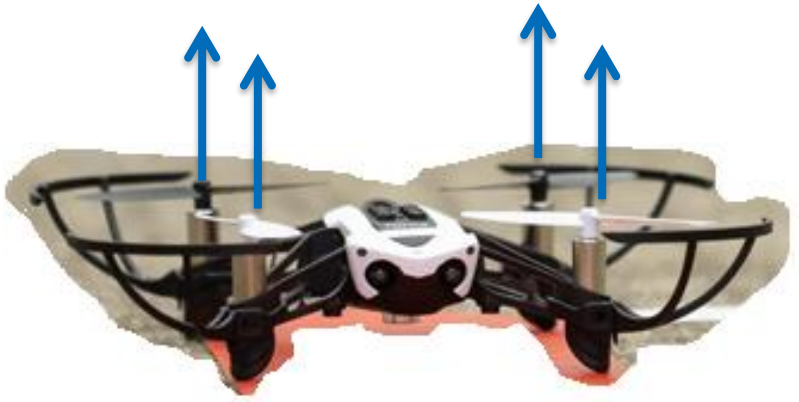
Drone

Controller

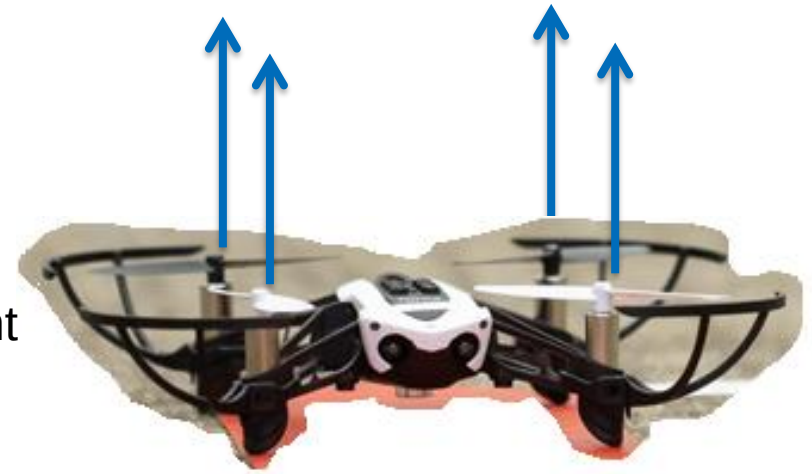
Assume drone is parallel to the floor



Drone overcomes the gravity force

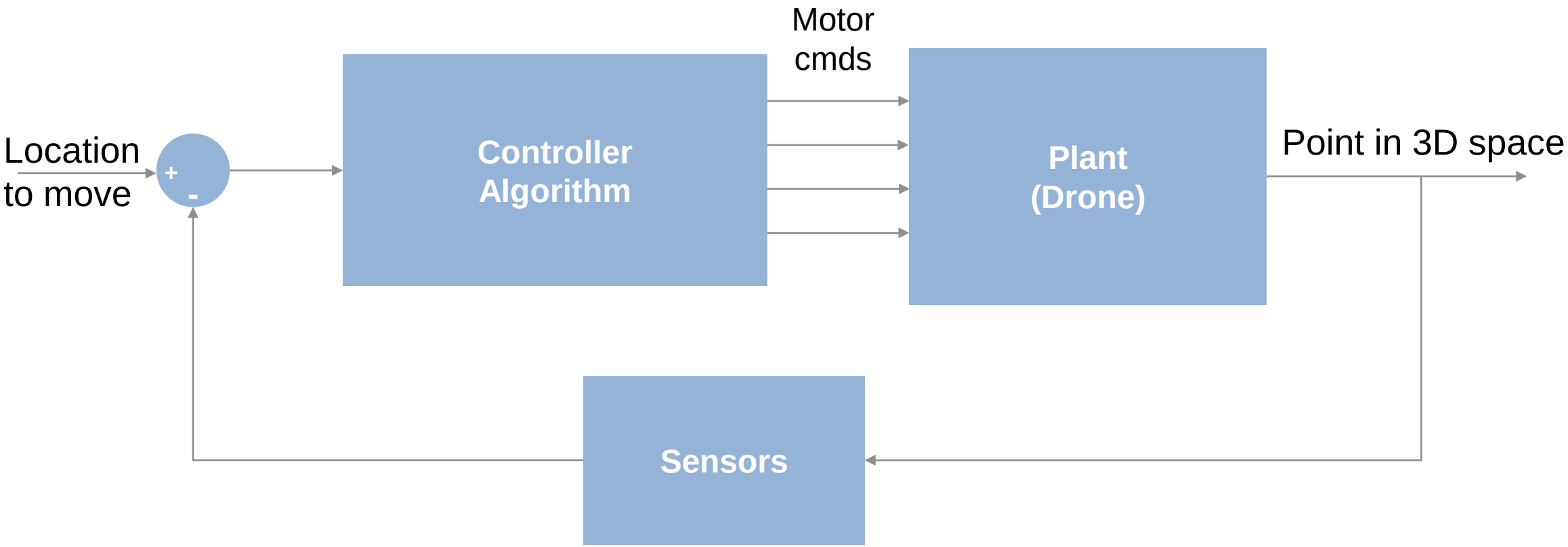


Increasing thrust -> Increased height

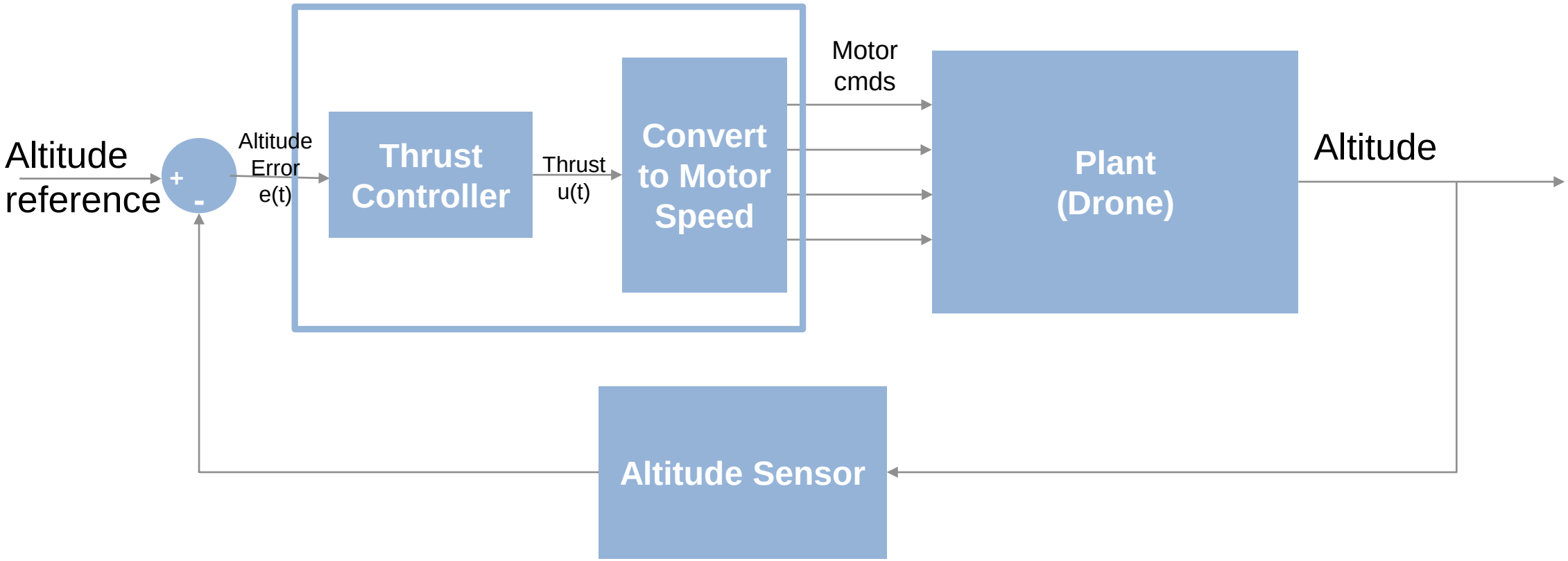


Decreasing thrust -> Decreased height

Modelling a drone



Controlling the altitude



PID controller

Proportional

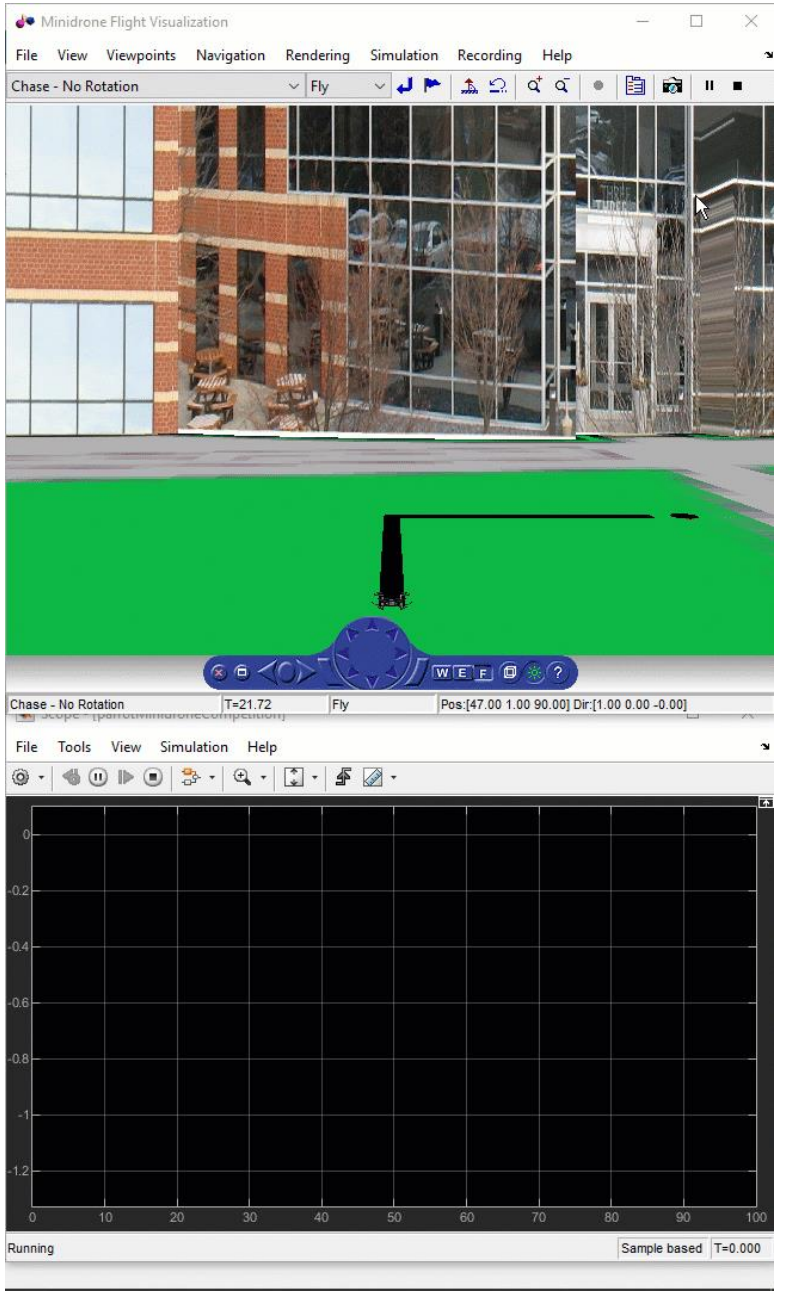
- $u(t) = KPe(t) + KI \int e(t)dt + KD \frac{de(t)}{dt}$

  $u(t)$: $Thrust$

  $e(t)$: $Error\ signal$

- $u(t) = K_P e(t)$
  - Thrust proportional to error

$K_P = 0.8$



PID controller

Proportional, Integral and Derivative

- $u(t) = KPe(t) + KI \int e(t)dt + KD \frac{de(t)}{dt}$

  $u(t)$: $Thrust$

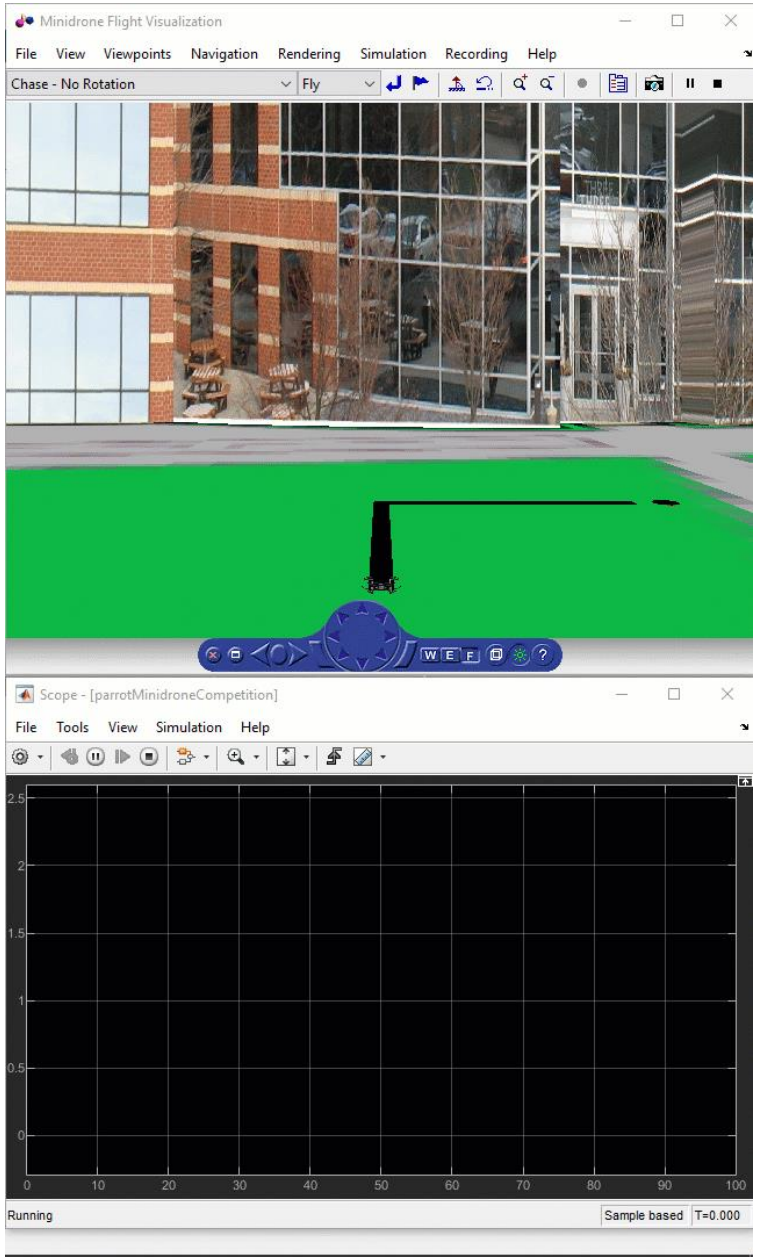
  $e(t)$: $Error\ signal$

- Derivative:
  - Understand the value of the future
  - Slow down for high rate of change
- Integral:
  - Keeps track of past value

$K_P = 0.8$

$K_I = 0.24$

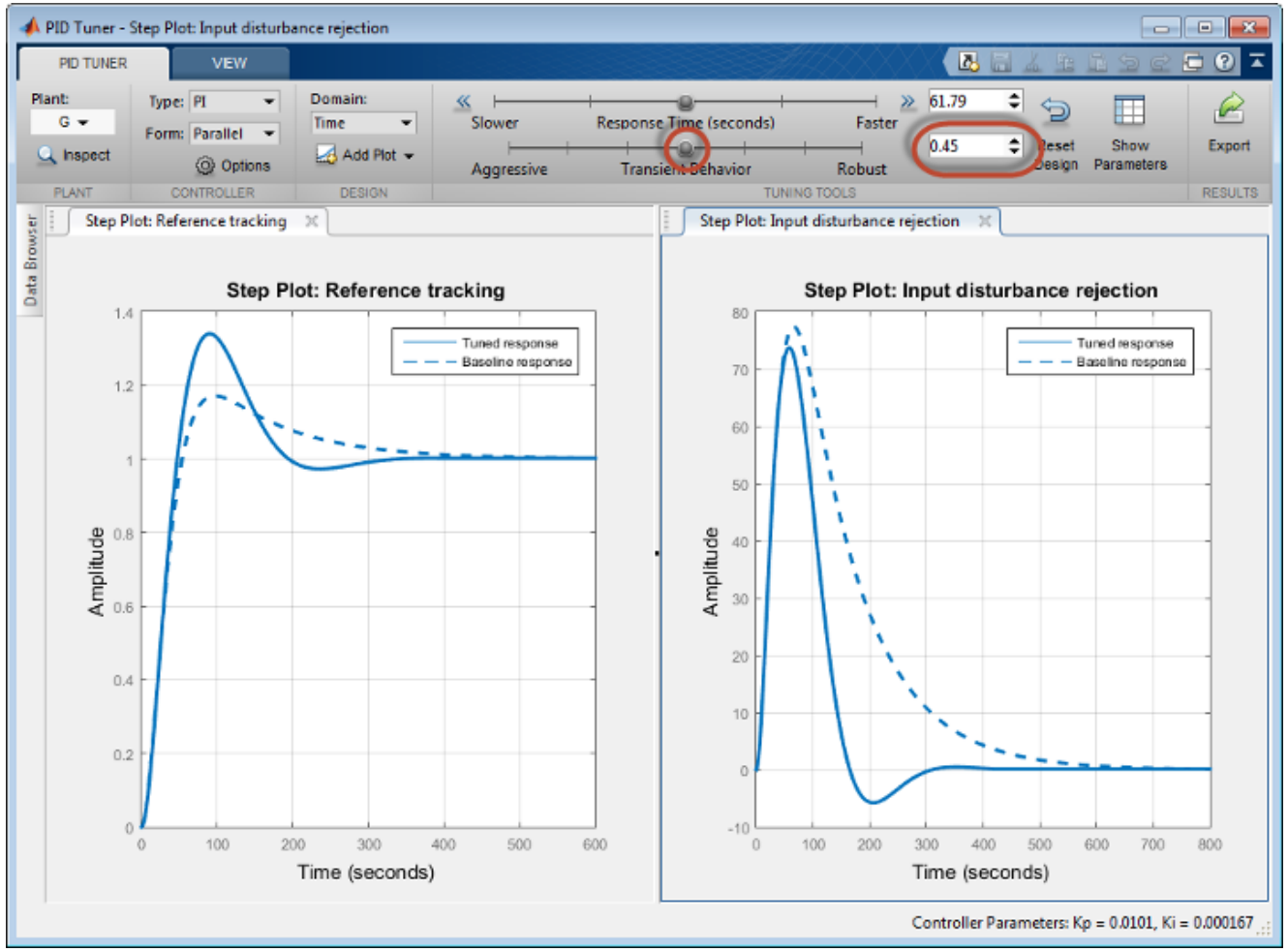
$K_D = 0.5$



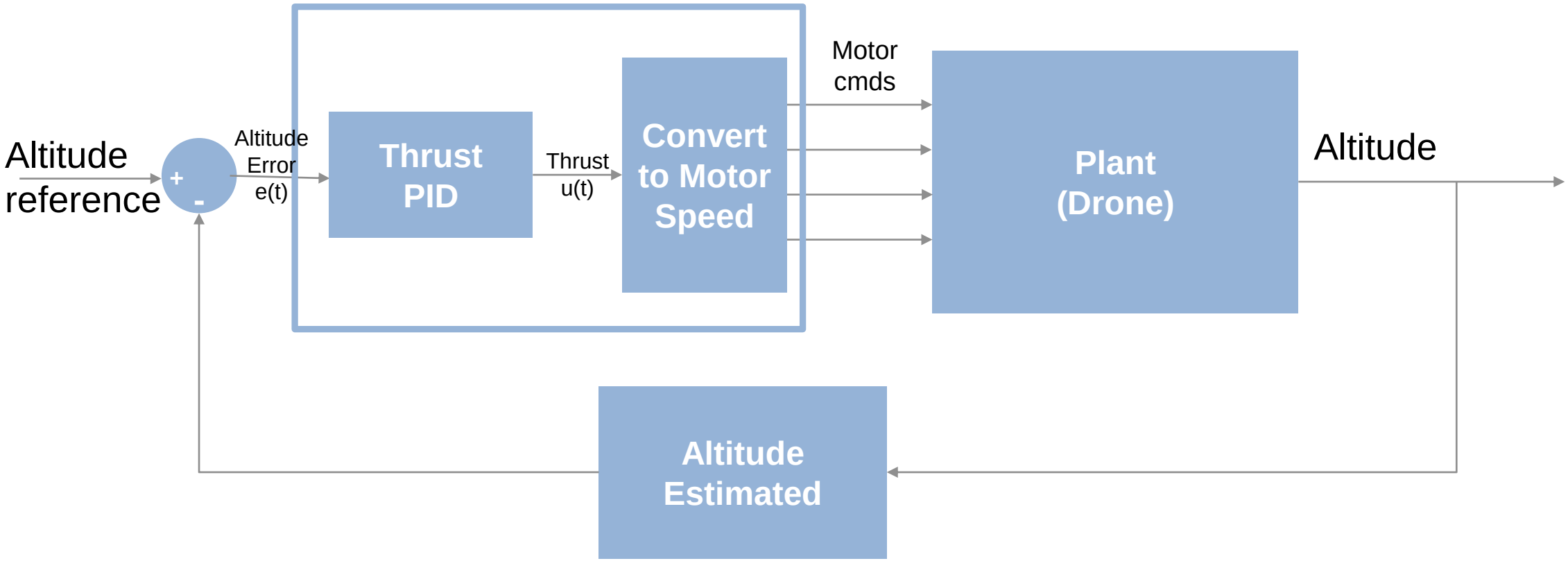
[parrotMinidroneHoverStart]

PID Tuner

For linear systems



Hovering at altitude

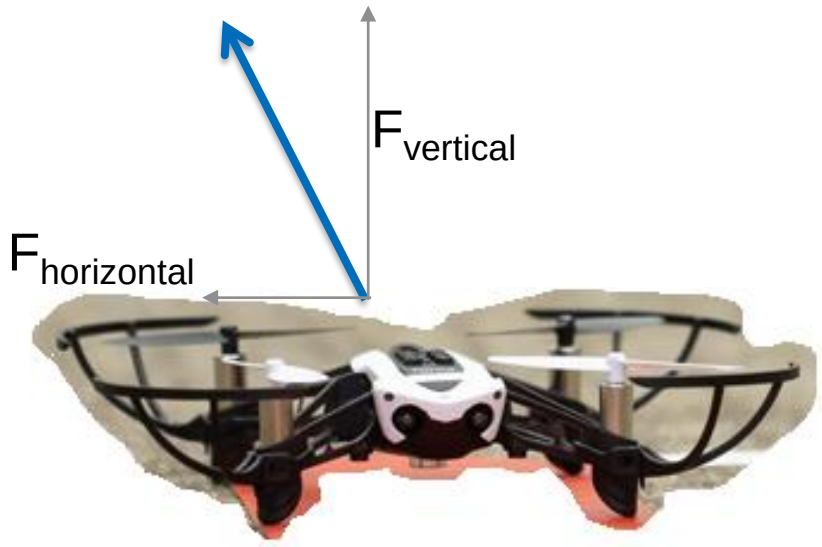


Assume drone is parallel to the floor

What if there are disturbances?

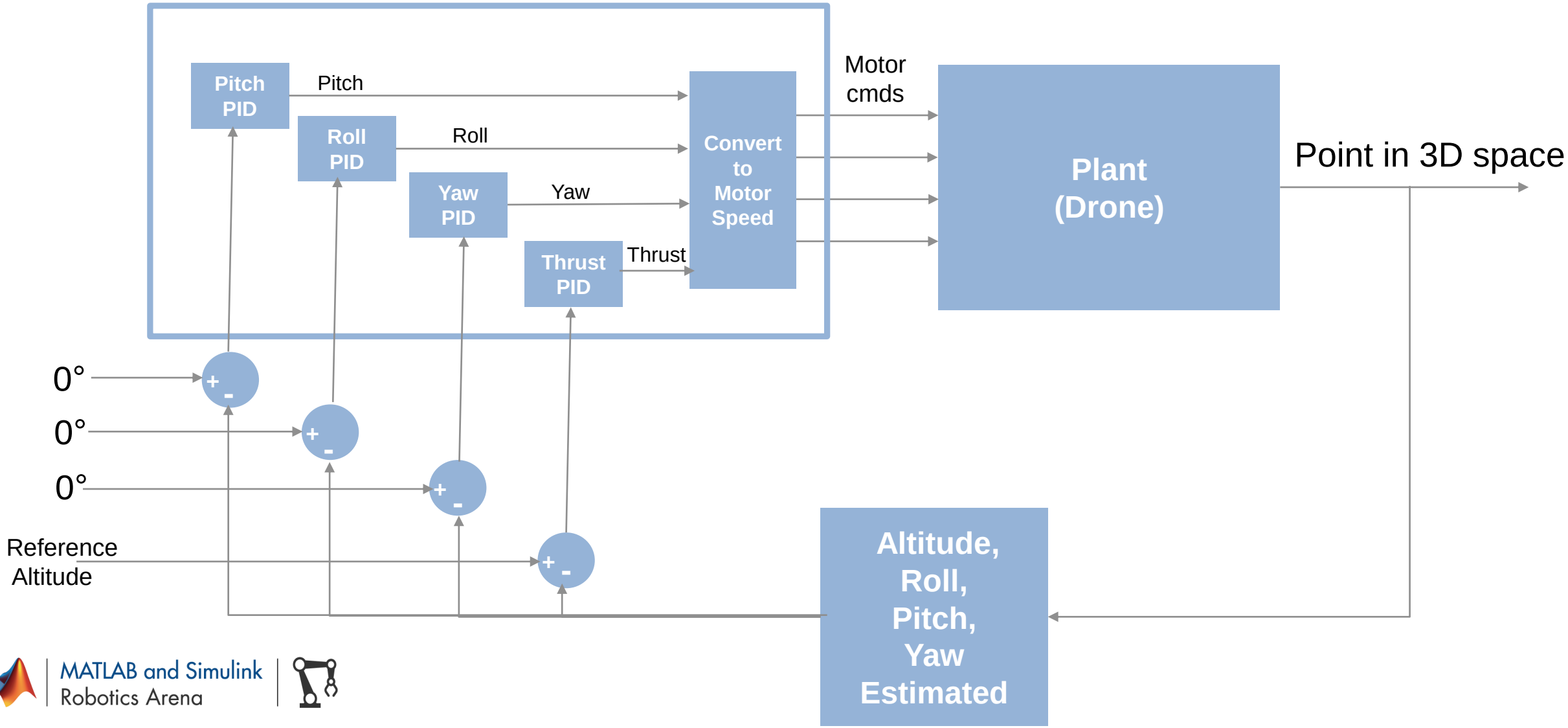
Problems faced

1. Height decreases ($F_{vertical}$)
   - Need to adjust the height
   - Altitude controller will take care of the height
2. Drone not parallel to the floor
   - Need a controller to set roll and pitch to 0
3. Horizontal drift to the sides ($F_{horizontal}$)
   - Need to get the drone back to original position



Controlling the drone

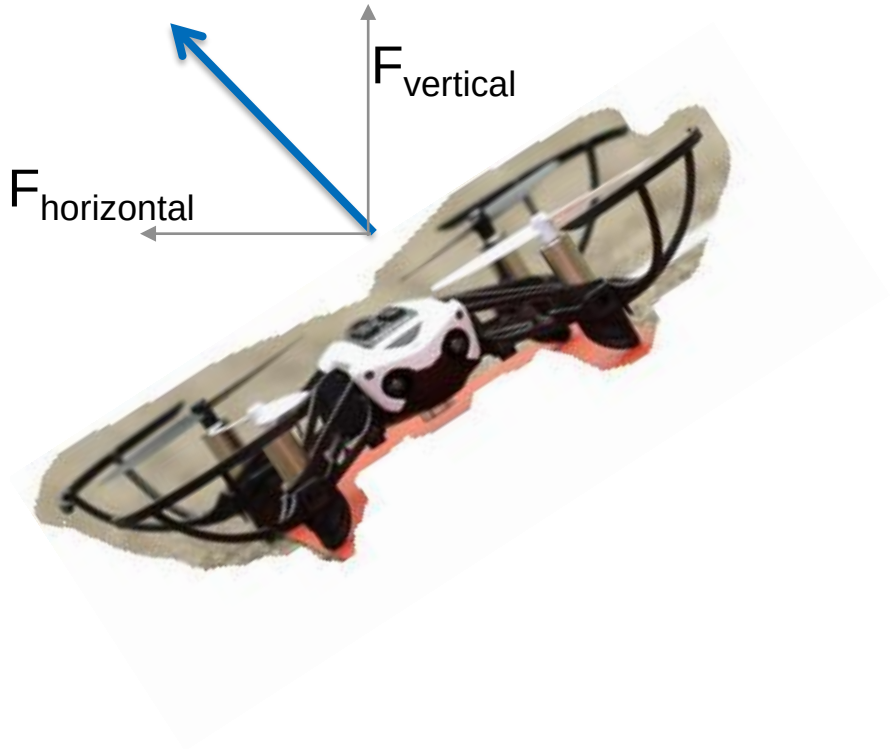
Problem 2:Drone not parallel to the floor



What if there are disturbances?

Problems faced

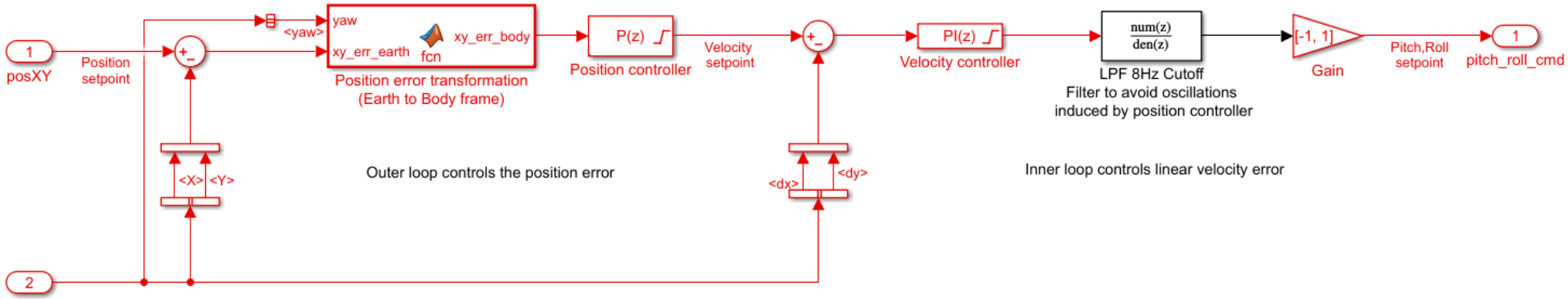
1. Height decreases ($F_{vertical}$)
   - Need to adjust the height
   - Altitude controller will take care of the height
2. Drone not parallel to the floor
   - Need a controller to set roll and pitch to 0
3. Horizontal drift to the sides ($F_{horizontal}$)
   - Need to get the drone back to original position



Controlling the drone

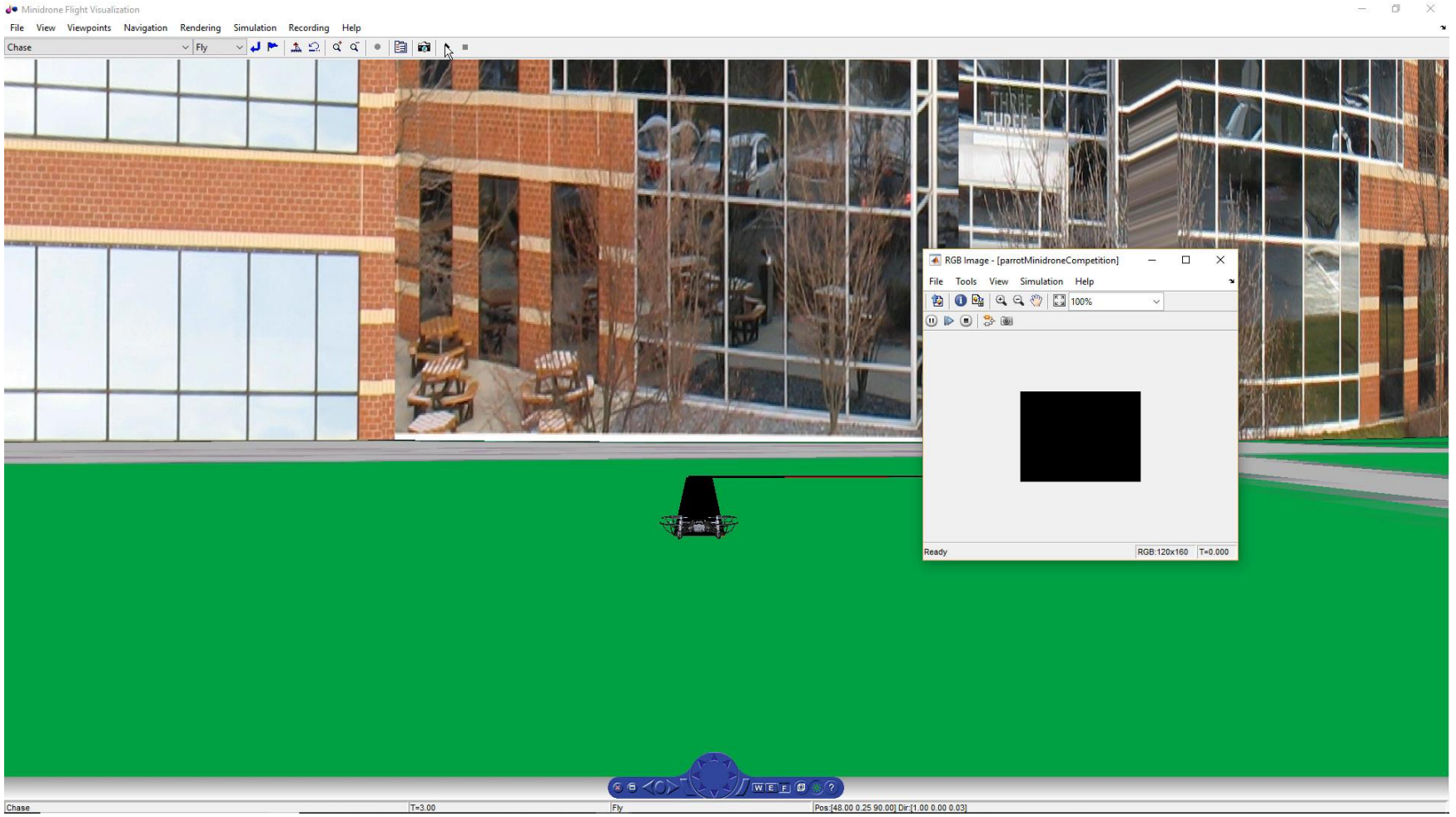
Problem 3: Horizontal drift to the sides

- Provide X, Y position references
- Use a controller to stay at the required position



Hovering the drone

In simulations

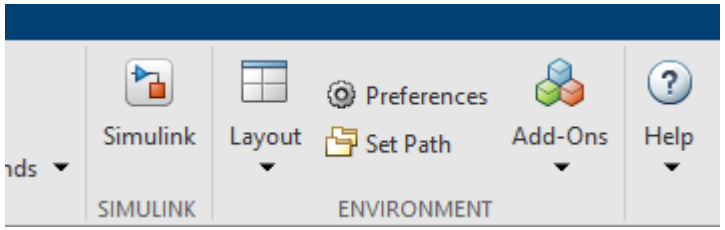


Hovering the drone

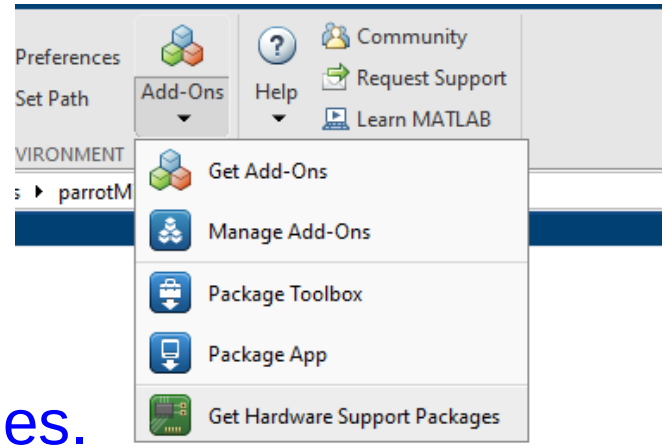
In real world

Installing the hardware support package

- Go to ‘Add-Ons’



- Select ‘Get Hardware Support Packages’



- Install [Simulink Support for Parrot Minidrones.]

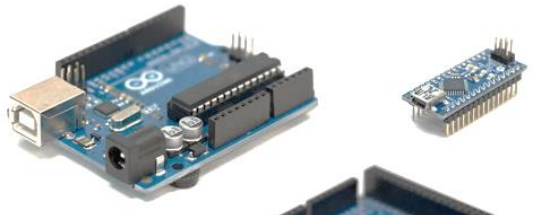
Deploying code on hardware

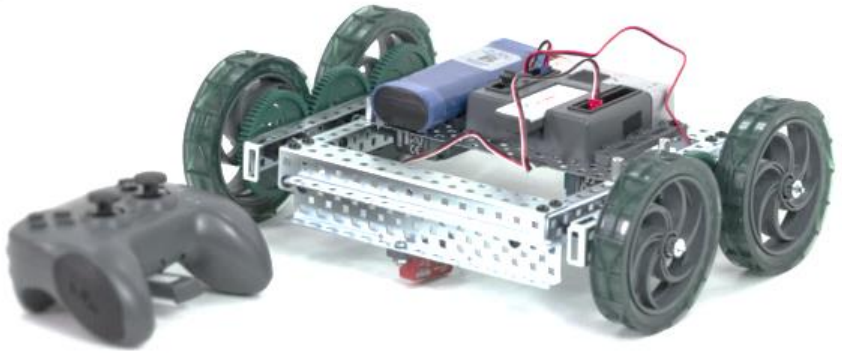
- Generate code from Simulink model
- Connect to hardware
- Run the model

Support for Low-Cost Hardware

- Parrot Mambo
- Arduino® Uno, Mega
- LEGO® MINDSTORMS® NXT
- Raspberry Pi
- BeagleBoard
- NVDIA Jetson
- RTL-SDR
- USRP

… and many more





Recommendations for Upcoming Webinar

- Complete Video Series on Drone Simulation and Control
- Install Simulink Support for Parrot Minidrones.
  - Try hands-on with us during/after the sessions

#droneseries
#Simulink
@MATLAB

How to access the Onramps/Tools to try hands-on?

- 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
- E-mail us at minidronecompetition@mathworks.com for access to license
  - First Name:
  - Last Name:
  - University/Institute:

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
- **Software offer**
  mathworks.com/academia/student-competitions
- **Racing Lounge blog:**
  blogs.mathworks.com/racing-lounge

Before Next Lesson!

- Complete Simulink Onramp
  - Tag with #Simulink #droneseries @MATLAB with the certificate on Social Media

- See video series on Drone Simulation and Control