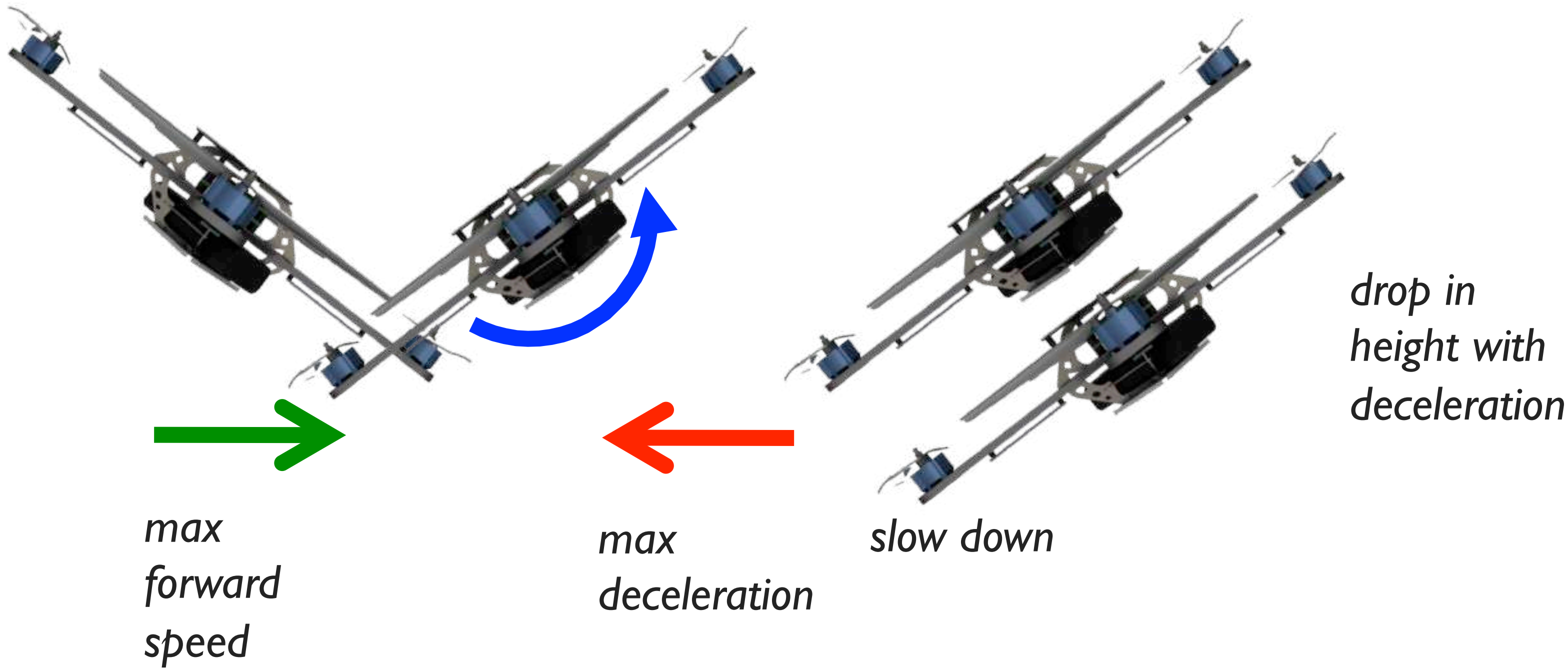
Goals

- Basic mechanics
- Control
- Design considerations
- Agility
- Component selection
- Effects of size

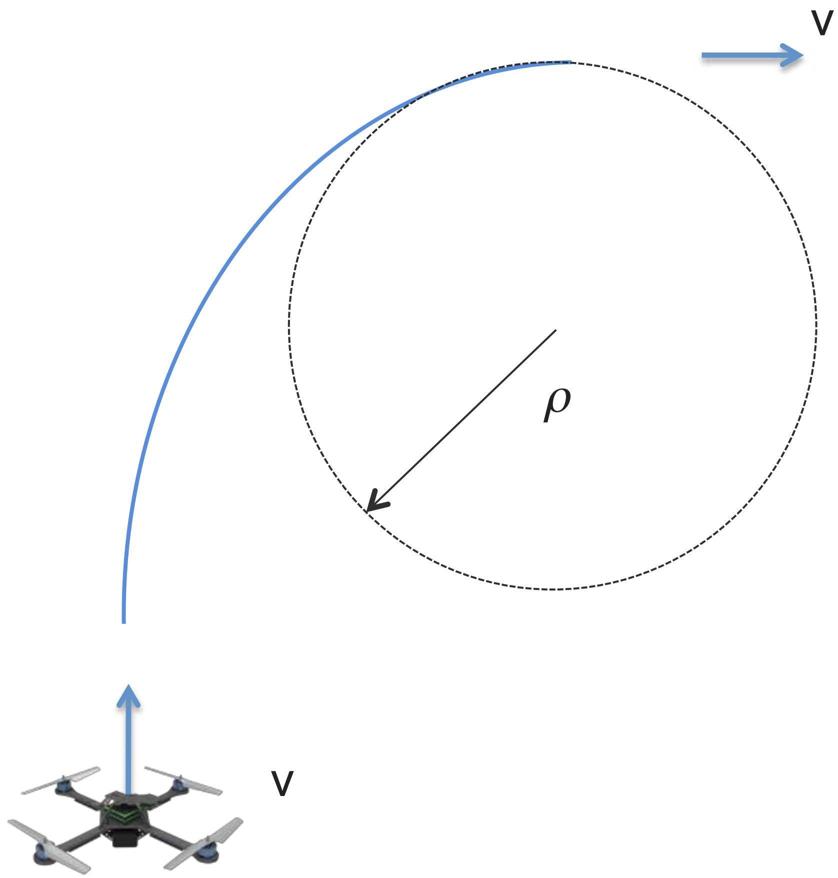
Agility

A. Maximum Velocity to Rest



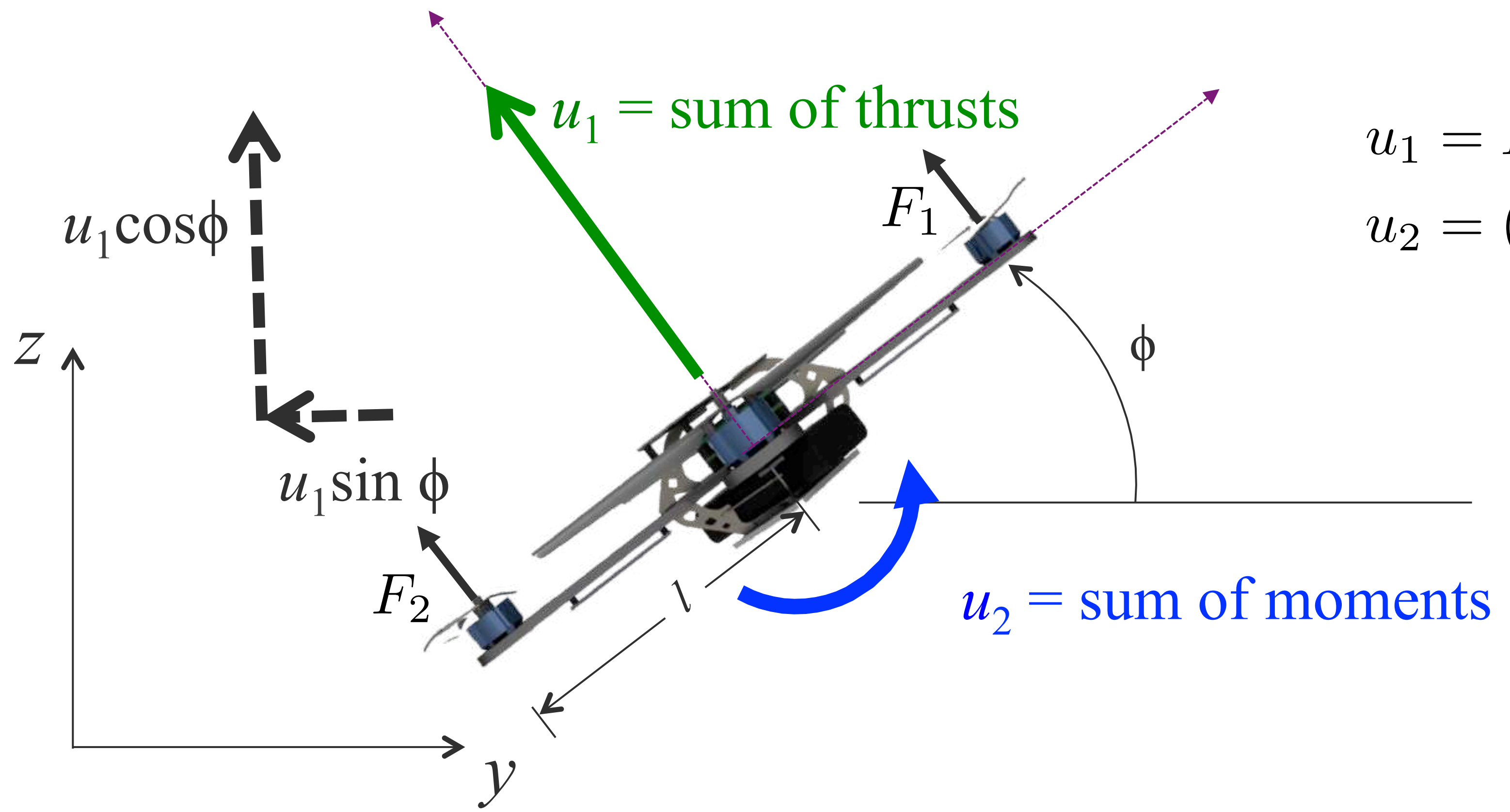
Maximize Agility: Minimize stopping distance

B. Turn Quickly without Slowing Down



Maximize Agility: Minimize minimum turning radius

Quadrotor in a Vertical Plane



$$u_1 = F_1 + F_2$$
$$u_2 = (F_1 - F_2)l$$

linear acceleration, a

angular acceleration, α

$$\begin{bmatrix} \ddot{y} \\ \ddot{z} \\ \ddot{\phi} \end{bmatrix} = \begin{bmatrix} 0 \\ -g \\ 0 \end{bmatrix} + \begin{bmatrix} -\frac{1}{m}\sin\phi & 0 \\ \frac{1}{m}\cos\phi & 0 \\ 0 & \frac{1}{I_{xx}} \end{bmatrix} \begin{bmatrix} u_1 \\ u_2 \end{bmatrix}$$

Agility

Two key ideas

- Accelerate quickly

$$\text{maximize} \quad a_{max}$$

linear acceleration

$$\boxed{\text{maximize} \quad \frac{u_{1,max}}{W}}$$

- Roll/pitch quickly

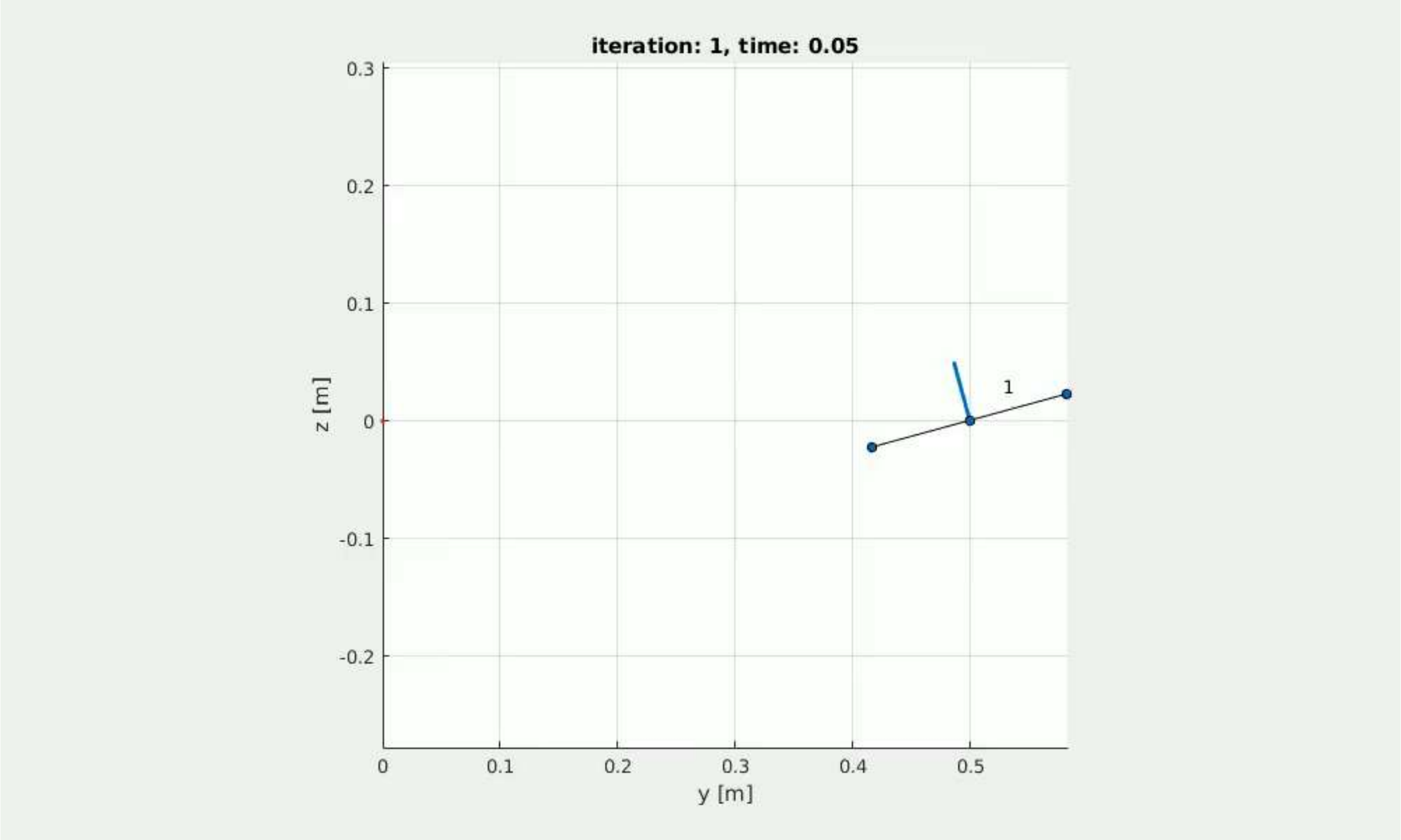
$$\text{maximize} \quad \alpha_{max}$$

angular acceleration

$$\boxed{\text{maximize} \quad \frac{u_{2,max}}{I_{xx}}}$$

Simulation

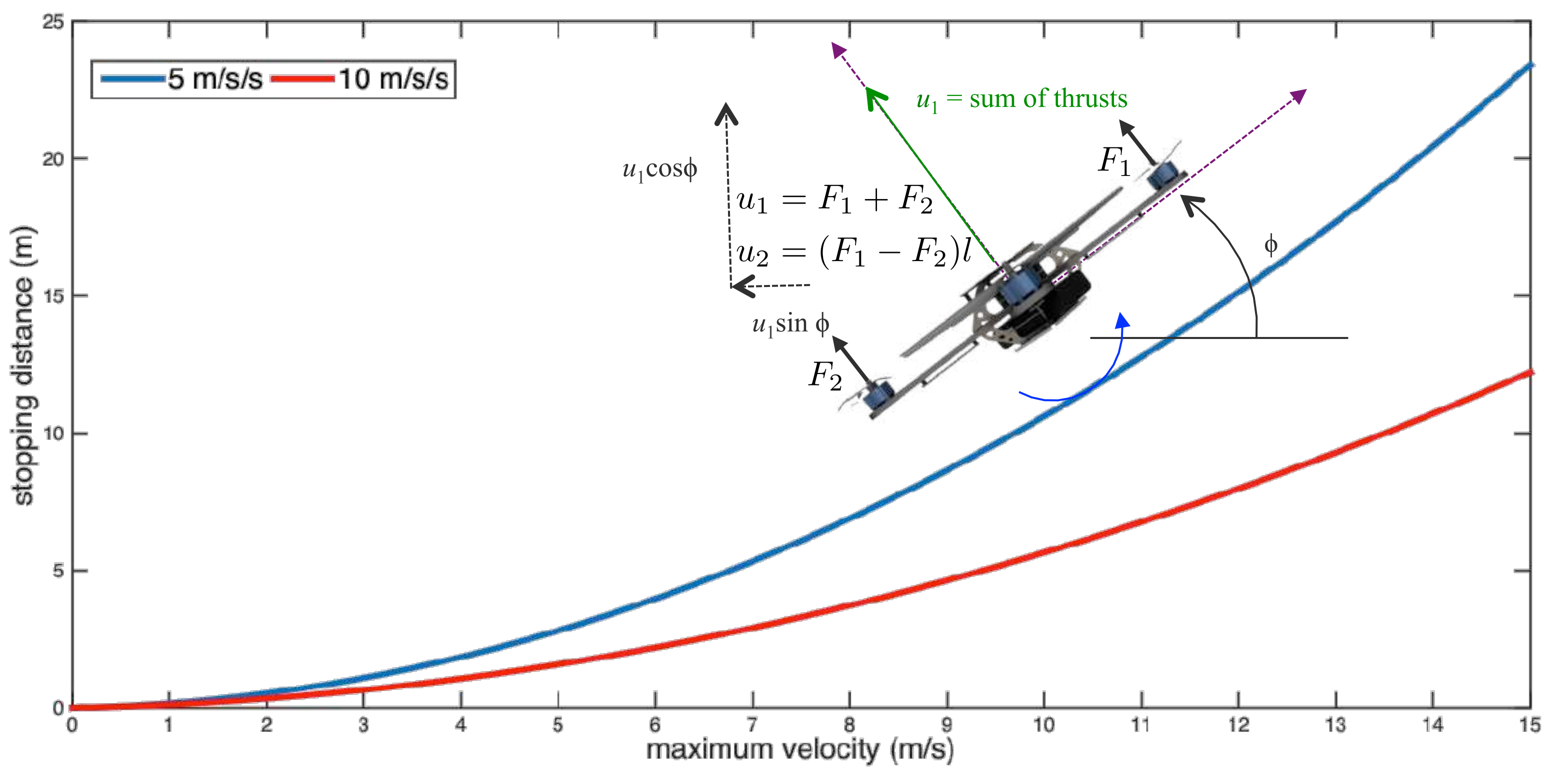
Max forward speed to zero speed



Stopping Distance

Assumptions

Thrust/weight ratio = 2
Assume robot can drop in height while turning
0 to 90 deg ~ 0.25 sec (1), 0.5 sec (2)
Conventional technology (e.g., dc motors, carbon fiber frame, li-po batteries)



Matlab Exercise

- In this exercise, we'll study how the initial velocity affects the stopping distance
- The robot is moving horizontally with the given initial velocity and it is commanded to stop
- You can change the initial velocity of the robot and run the simulation to find out the distance required* for stopping.
- What is the maximum initial velocity for which the stopping distance is less than 6m?

**Note that during this maneuver, the robot will also lose height.*