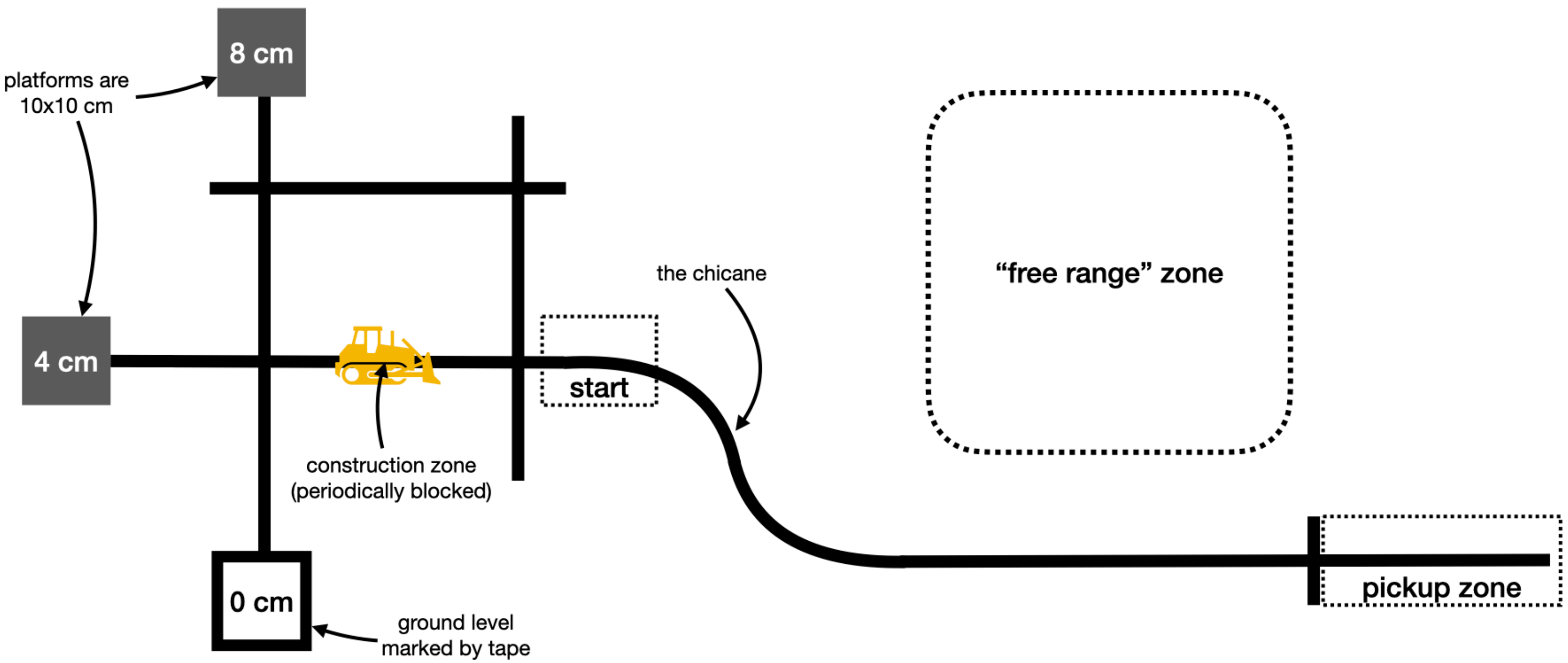
Delivery Robots

FOMRE NSF Workshop

A Brief History

The Challenge



Activity 1: Move It!

A few warnings!

- The ON/OFF button only controls the drive motors!
- The servo will run off of USB, but the provided cable is too weak to power it.

PID Control

- PID control is a common control method, and the theory behind it scales well to the students' ability

Control loops

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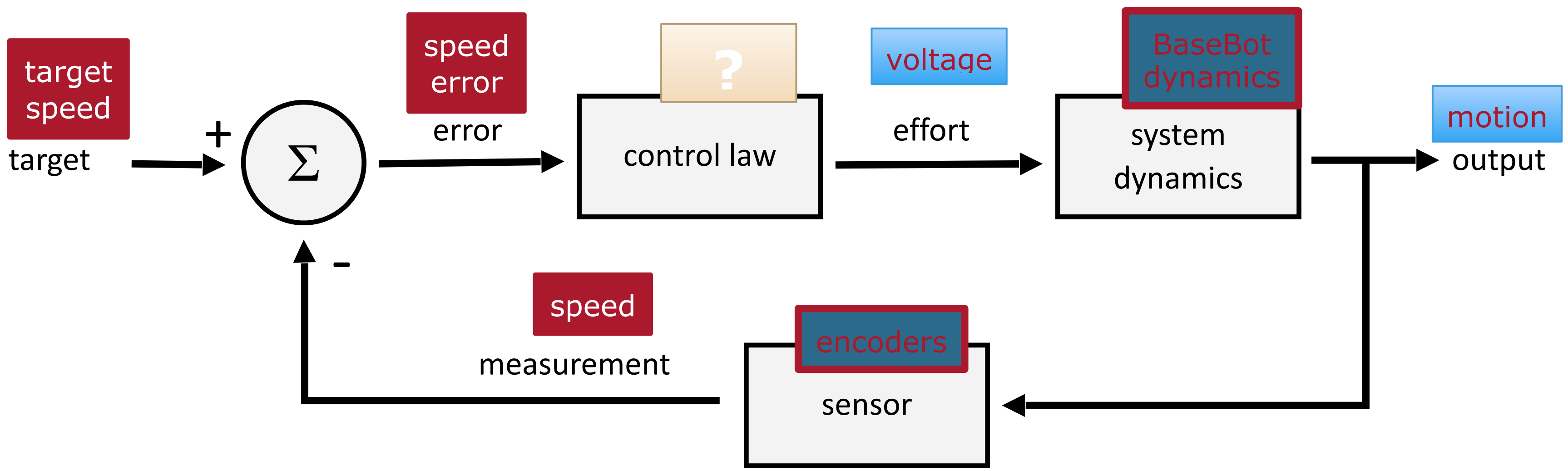


Demo: Set PID Coefficients

- PID control is a common control method, and the theory behind it scales well to the students' ability

Warning: Before you get started, check the values sent to setWheelSpeeds() in drive()

```
// A helper command to drive a set distance
void drive(float dist, float speed)
{
  Serial.println("drive()");
  setLED(HIGH);
  robotState = ROBOT_DRIVE_FOR;

  chassis.setWheelSpeeds(10, 10);
}
```

Calibrating the kinematic parameters

- You want to be confident that when you tell the robot to drive 50 cm, it drives 50 cm.
- And when you tell it to turn 90 degrees, it does.

- You can measure the robot and use values from the datasheet, but calibrating will give you better performance.

Distance

The distance a robot will travel, given a wheel diameter and a wheel rotation (in degrees), and

Solution: From the definition of a radian, the distance (length), L, that the robot will travel for a given wheel rotation is just the radius of the wheel times the angle, θ – **in radians** – that it turned.

$$L = \theta(rad) \cdot \frac{d}{2} = \boxed{\theta(deg) \cdot \frac{\pi}{180} \cdot \frac{d}{2}} \tag{1}$$

- For ν encoder counts / revolution:

$$\theta(deg) = N \cdot \frac{360}{\nu}$$

$$\boxed{L = N \cdot \frac{\pi d}{\nu}}$$

Angle

The angle a robot will turn, given a wheel diameter, wheel track, and a wheel rotation (in degrees).

$$\phi(deg) = \frac{360L}{\pi D} = \frac{360}{\pi D} \cdot \theta(deg) \cdot \frac{\pi}{180} \cdot \frac{d}{2} = \boxed{\frac{d}{D}\theta(deg)}$$

- For ν encoder counts / revolution:

$$L = N \cdot \frac{\pi d}{\nu}$$

$$\phi(deg) = \frac{360}{\pi D} \cdot L = \frac{360}{\pi D} N \cdot \frac{\pi d}{\nu} = \boxed{360 \cdot \frac{N}{\nu} \cdot \frac{d}{D}}$$

Task: Perform experiments to calibrate the motion

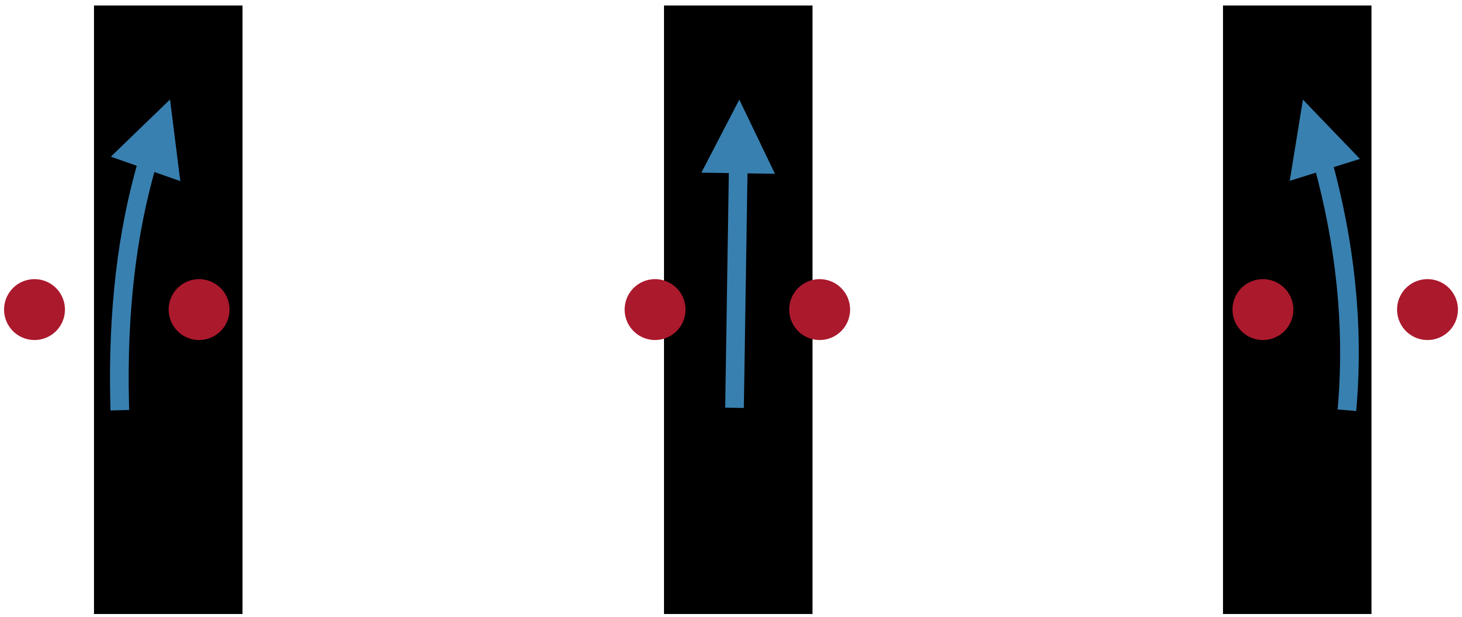
- Command the robot to drive 50 cm
- Measure how far it actually went
- Adjust the parameters until it drives the correct distance

- Then do the same with turning
    - You’ll need to add the commands to handleKeyPress()

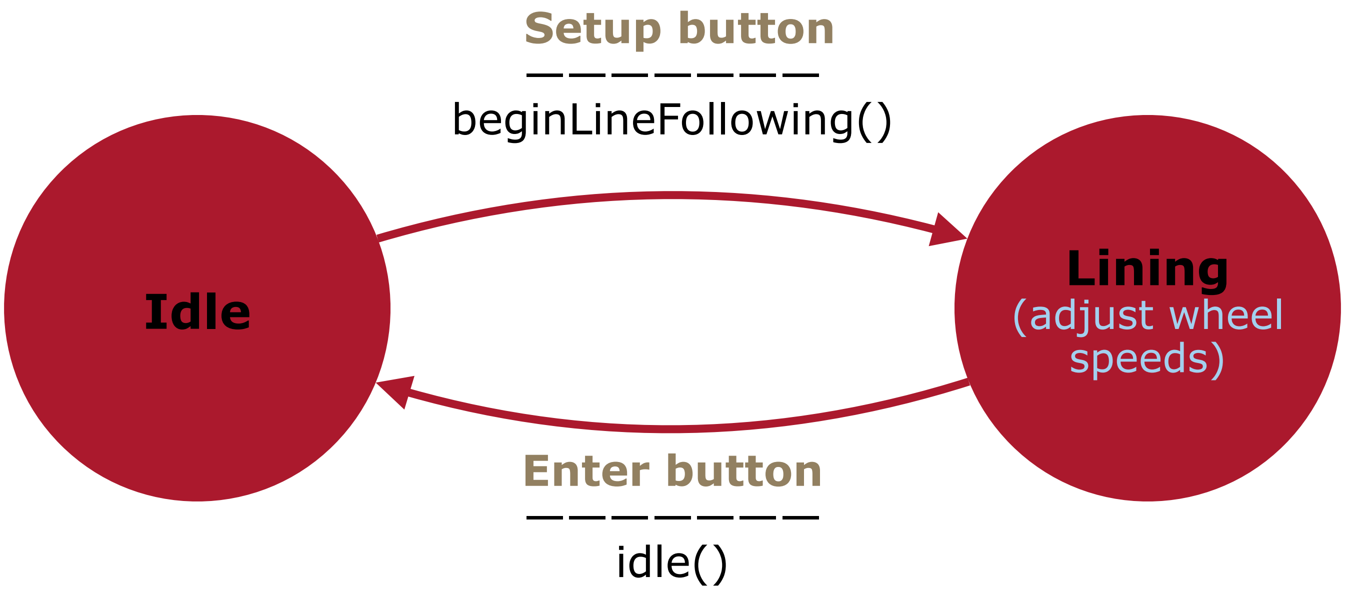
Activity 2: Staying on Track

Line following

- Line following is a common method for path following
- Our general strategy will be to read both line sensor elements and compare them

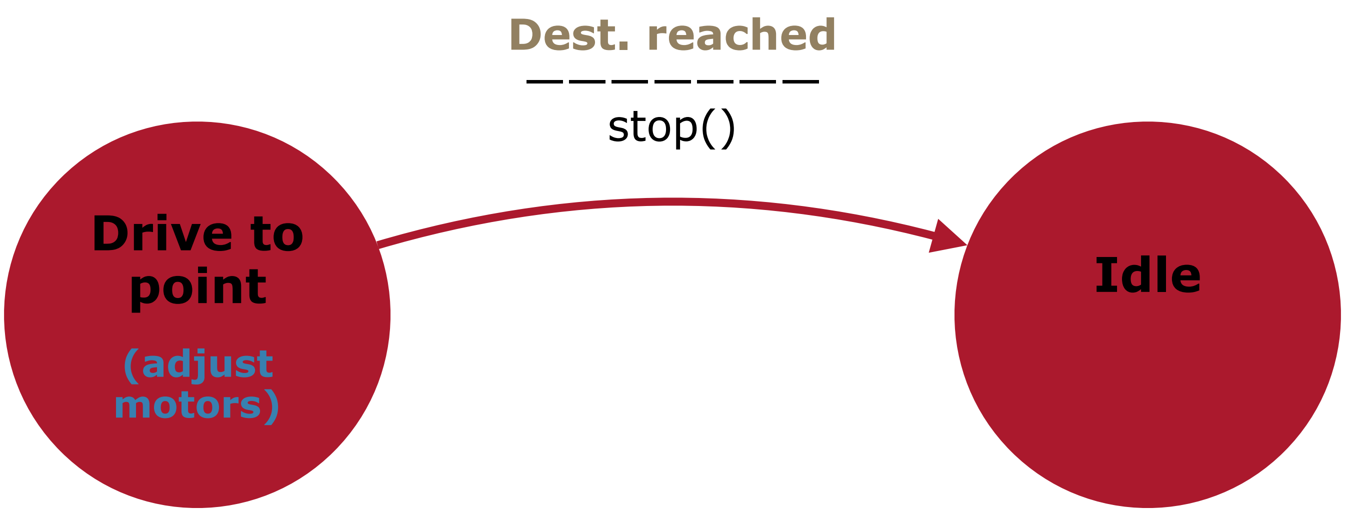


State machine

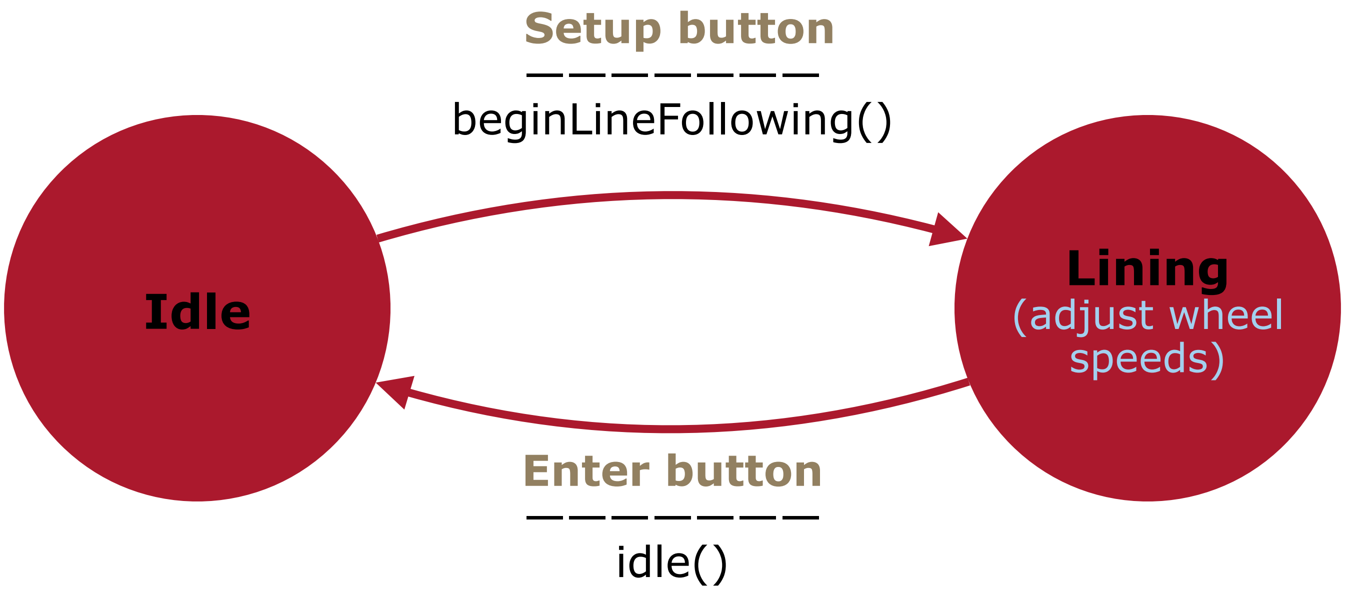


Maintenance and achievement goals

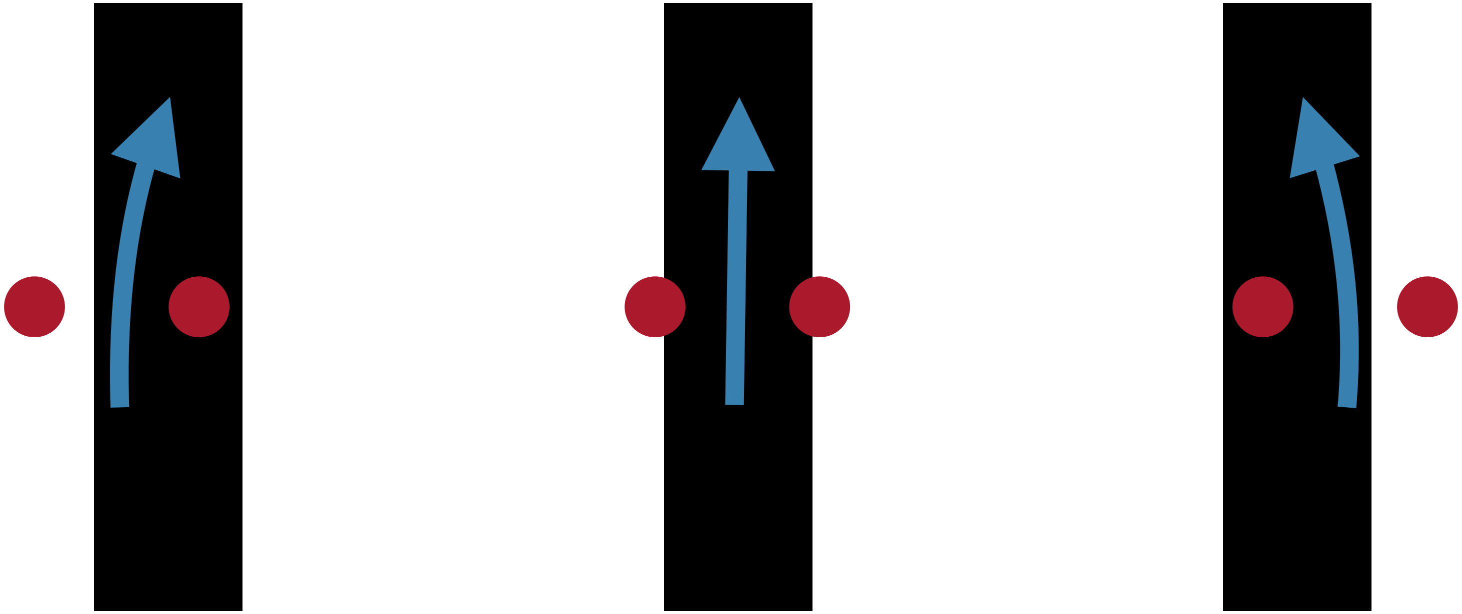
- *Achievement goals* generally correspond to *events* — when you get something done, it's time to move to a new task
- *Maintenance goals* are associated with ongoing activities and typically associated with a *state*



State machine



Task: Line following



Detecting intersections

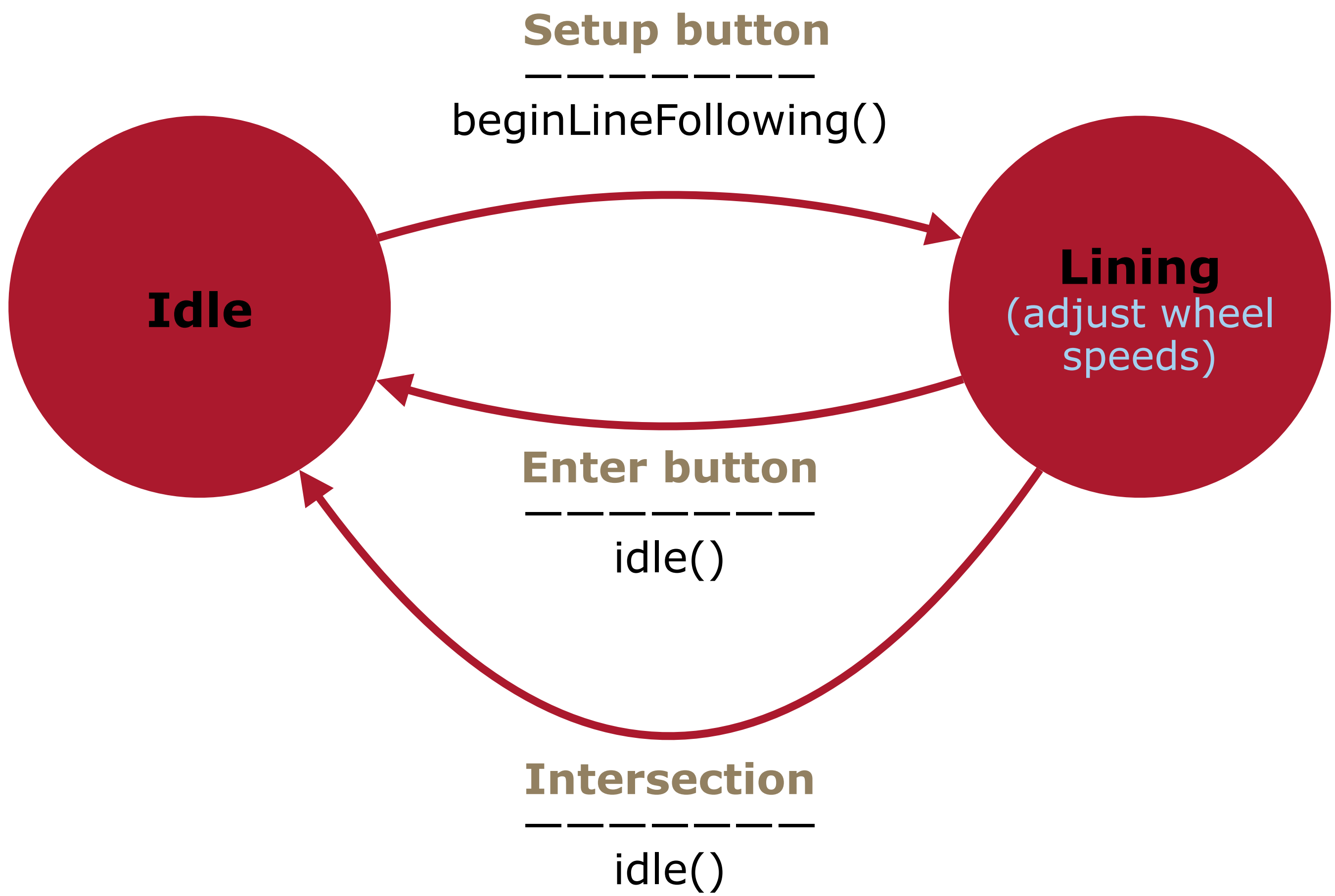
- Motivates a discussion of *event detection*
  - (short demo, time permitting)

Event detection

- An intersection is denoted by *both* sensors reading a dark surface.
- The *event* of reaching an intersection occurs when the sensors did not previously detect an intersection and now they do

		before	
		no	yes
now	no	F	F
	yes	**T**	F

Intersection



Activity 3: The Heavy Lifting

Mechanics

- Students are introduced to mechanics
  - Motors don’t provide infinite torque
- Motivates a discussion of tradeoffs

Picking up a bag: Two methods

- Look, then drive: Measure the distance and drive that amount
  - Hard to get correct
- Drive and look: Drive towards the bag and stop when it gets to the right distance

In my solution, I actually used a combination of the two: drive until Romi gets close, then dead reckon the last bit.

Experiment vs. analysis

- We typically have the students solve a standard configuration, then give them a tool to help them explore other solutions

Experiment vs. analysis

- We typically have the students solve a standard configuration, then give them a tool to help them explore other solutions

“The difference between theory and practice is nothing in theory, and everything in practice.”

Unanticipated interactions

- Lifting a bag motivates a discussion of unintended interactions
  - The line sensor values may change when the robot is carrying a heavy load
  - Heading corrections and turning typically become more “jerky”
  - Depending on the arm configuration, the bag may interfere with the ultrasonic rangefinder