MS4SSA
Robotics Module:

Programming and Sensors

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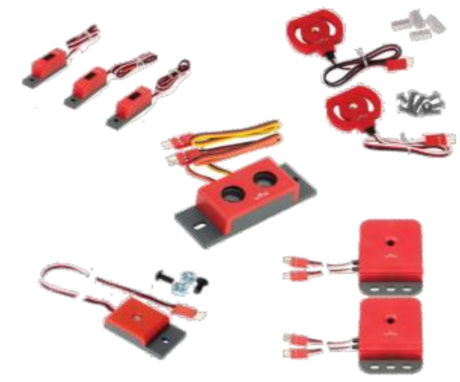
Why Program a Robot?

- Building a robot teaches many valuable skills; however, the learning doesn’t stop there
- Programming also teaches valuable life skills
  - Problem Solving
  - Creative and Computational Thinking
  - Team Building
- Robotics provides hands-on activities that help stimulate thinking, excite and engage students
- Robots help students see how what they are learning has a direct impact on the world – and how the math and engineering elements can help guide solutions for real life problems

System Components

VEX Microcontroller

VEX Joystick



Sensors

VEXnet Key

USB Tether Cable

Actuators
(motors and servos)

What is a Program?

- Programs are steps, or instructions that you want the robot to follow

STEPS	CODE

Start driving forward
 	
Wait 2 seconds
Turn for 1000ms
	`motorSet(1, 60);`
	`motorSet(10, -60);`
	`delay(2000);`
	`motorSet(1, -60);`
	`delay(1000);`

- There are many different options for languages to use for programming. Today we are using C programming language and Purdue Robotics Operating System

PROS

Functions

- A name given to a group of steps so you can refer to it later
- Makes the program more readable
- Simplifies multiple lines of code into a single command
- The steps for a function appear inside of braces {}
- The steps can optionally produce a result or just do some work

Functions

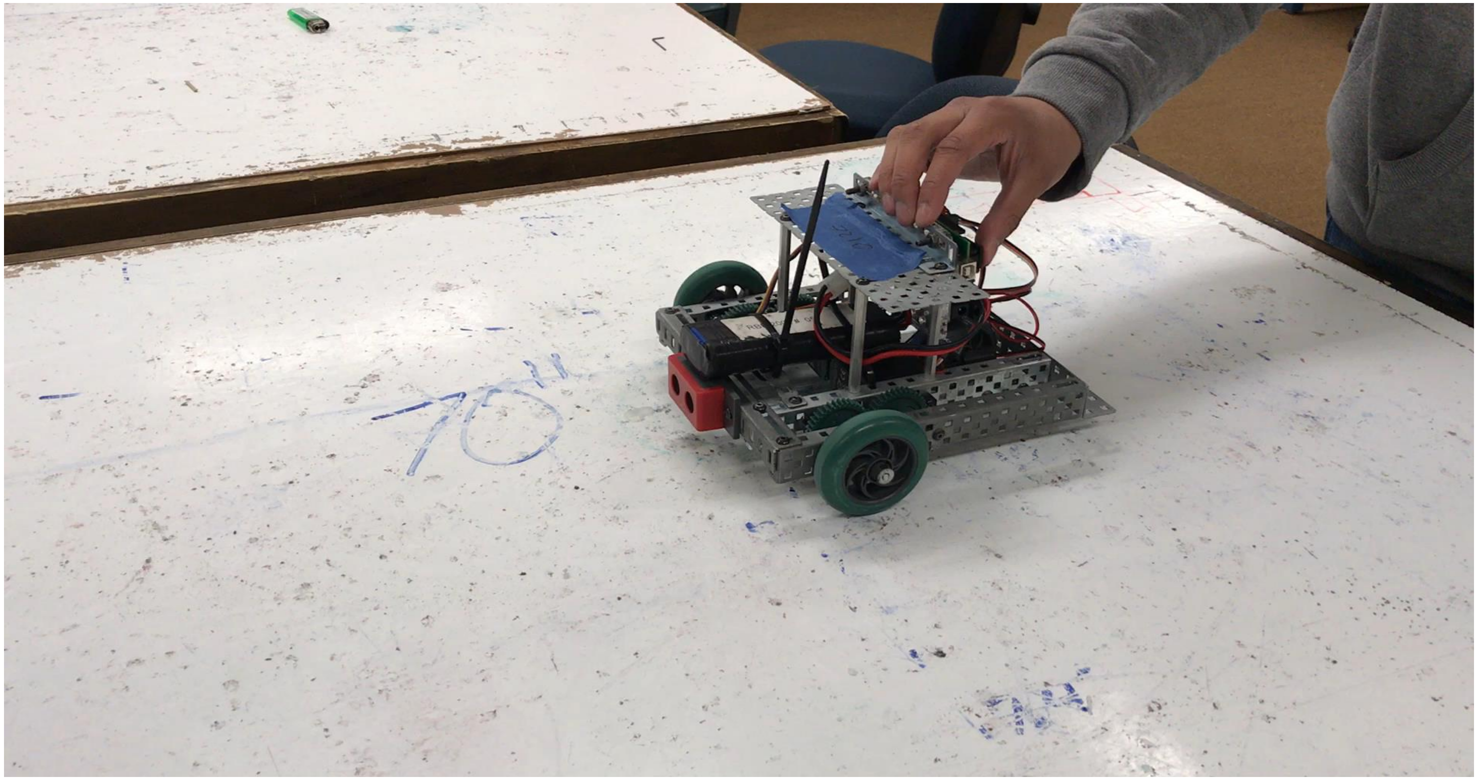
- For the program today, we created these functions:

```
void driveForward(int time){
        motorSet(1,60);
        motorSet(10,-60);
        delay(time);
        motorStopAll();
}

void turnRight(int time){
        motorSet(1,60);
        motorSet(10,60);
        delay(time);
        motorStopAll();
}
```

Your First Challenge

You start with this program…



and make the robot drive in a square instead

Driving Straight


```
void driveForward(int time){
        motorSet(1,60);
        motorSet(10,-60);
        delay(time);
        motorStopAll();
}
void turnRight(int time){
        motorSet(1,60);
        motorSet(10,60);
        delay(time);
        motorStopAll();
}
void operatorControl() {
        while (1) {
                driveForward(1000);
                delay(500);
                turnRight(500);
                delay(500);
        }
}
```

Set motors to drive forward for “time”

Set motors to turn for specified “time”

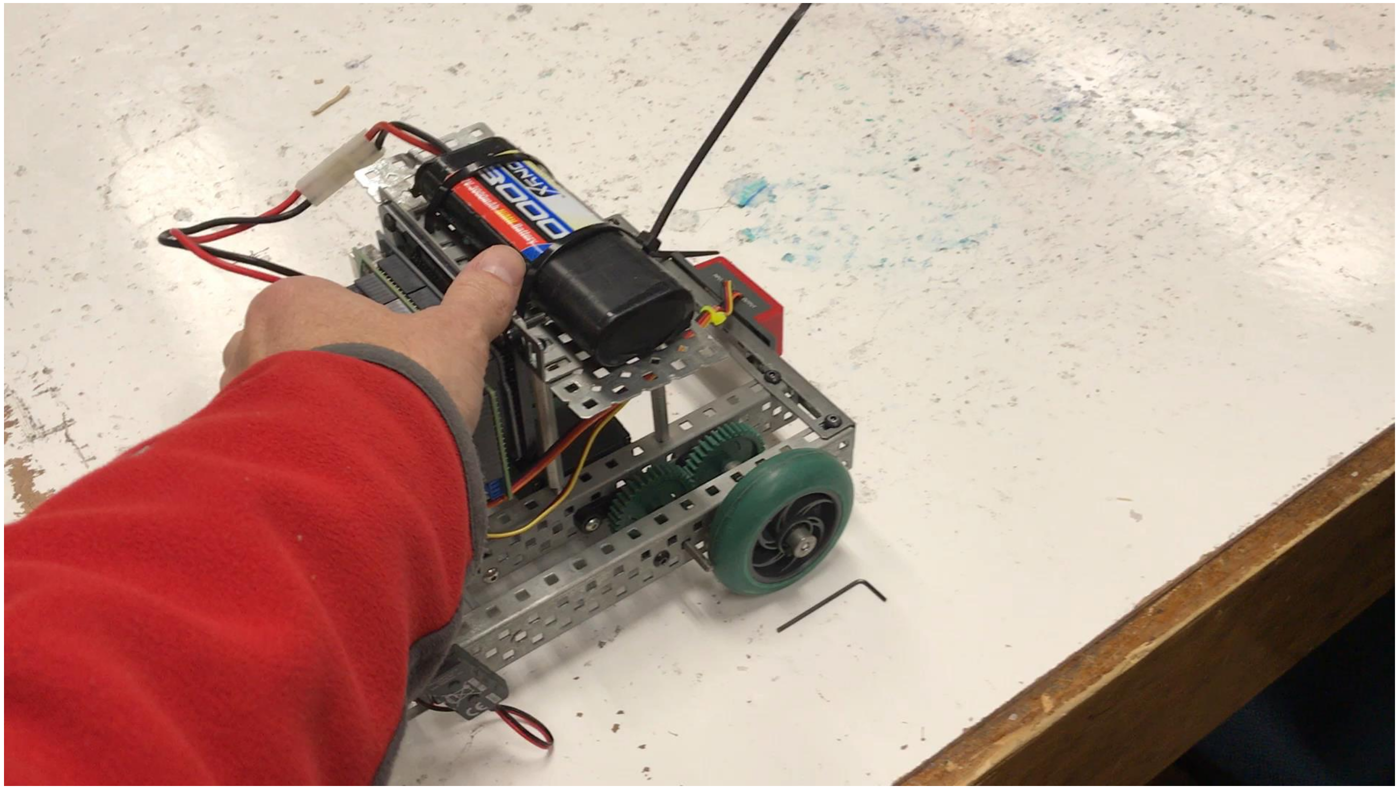
Continuous loop of
driving x millisec
pause x millisec
turning x millisec
pause x millisec

Make a Square

- Now, your job is to change the program to make the robot turn in a square

Your Second Challenge

Drive until 10cm from wall, then stop



Use a Sensor

Sensors allow the robot to understand it’s state and the world around it

Ultrasonic rangefinder gives the distance to an object in centimeters

Rangefinder


```
Ultrasonic sonar;

void operatorControl() {
        sonar = ultrasonicInit(9, 8);
        while(1){
                if(ultrasonicGet(sonar)>10){
                        motorSet(1,60);
                        motorSet(10,-60);
                        delay(100);
                }
                else{
                        motorStopAll();
                }
        }
}
```

What went wrong?

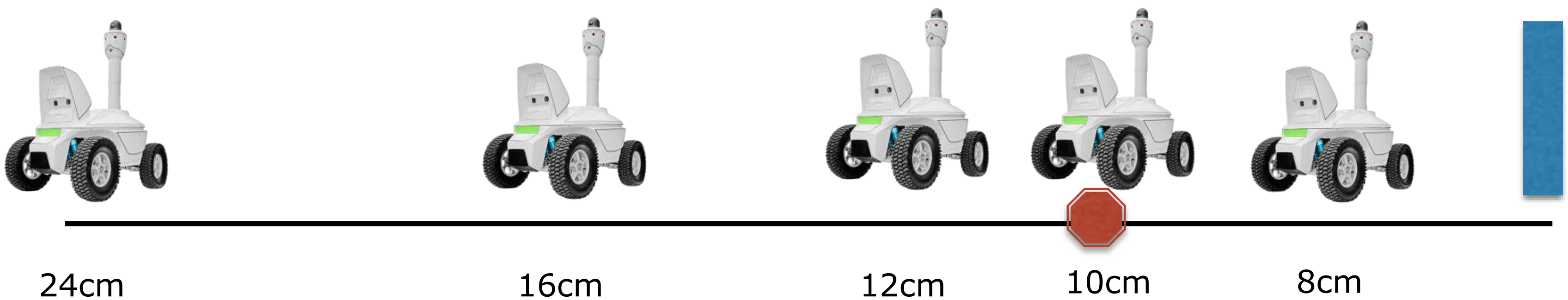
- Inertia carries robot past 10 cm
- What can we do?
  - Stop 12cm from wall to allow 2cm of coasting?
- What's wrong with this strategy?
  - Differences in battery charge
  - Differences in driving surface
  - Differences in slope
  - etc…

Use proportional control!

Proportional Control

We want the robot to stop 10cm from the wall so the *target distance* or **set point** is 10

Compute the distance from the set point and call it the **error**



error=14 error=6 error=2 error=0 error=-2

Make the robot driving speed **proportional** to the error.
As the error gets smaller, the robot drives more slowly.
The speed is a function of the error.

Proportional Gain

24cm	16cm	12cm	10cm	8cm
error=14	error=6	error=2	error=0	error=-2
speed = 42	*speed = 18*	*speed = 6*	*speed = 0*	*speed = -6*

These error values are too small to make the motors move

Solution:
We can multiply the values by some constant (Kp) to make the values big enough to drive the motors
for example: Kp = 3

What if Kp is too small?

Kp = 1

error=16
speed=16

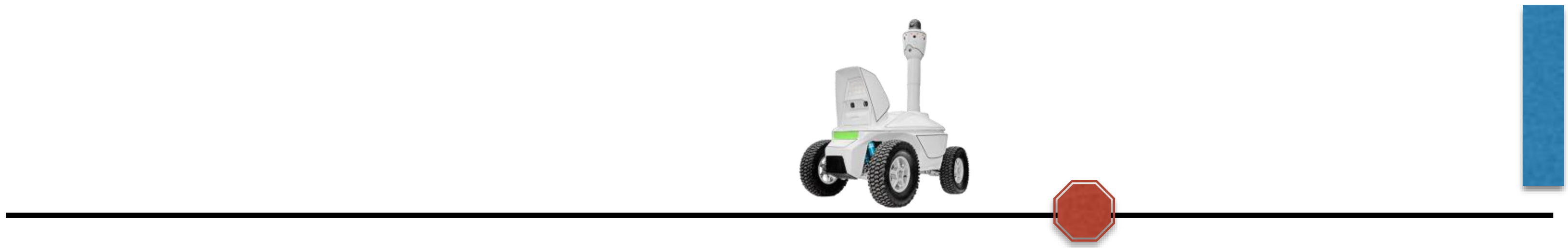
What if Kp is too small?

Kp = 1

error=3
speed=3

What if Kp is too small?

Kp = 1

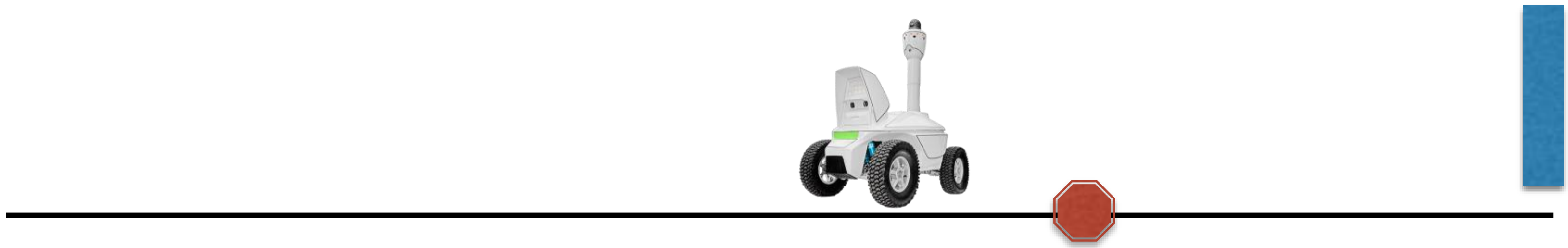


error=2
speed=2

A speed of 2 is too little
to make the motors turn

What if Kp is too small?

Kp = 1



error=2
speed=2

The robot never reaches the set point!

What if Kp is too large?

Kp = 10

error=24
speed=240

What if Kp is too large?

Kp = 10

error=5
speed=50

What if Kp is too large?

Kp = 10

error=2
speed=20

What if Kp is too large?

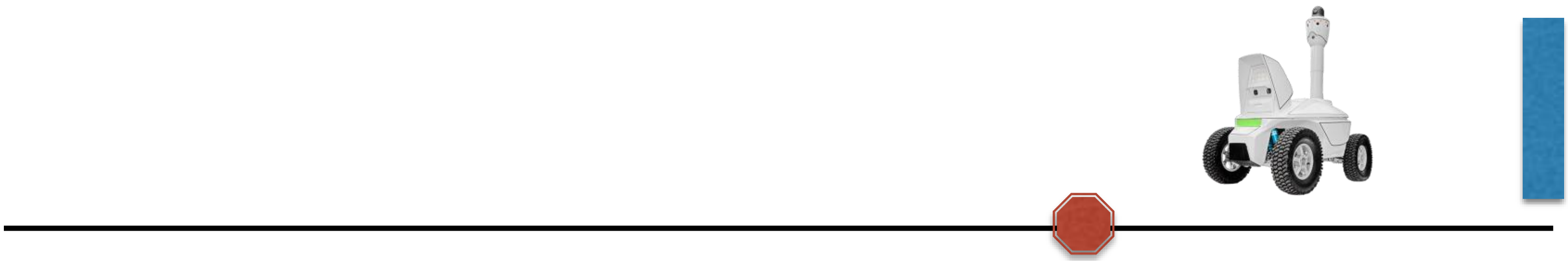
Kp = 10

error=0
speed=0

But we’re going so fast that the robot can’t stop

What if Kp is too large?

Kp = 10

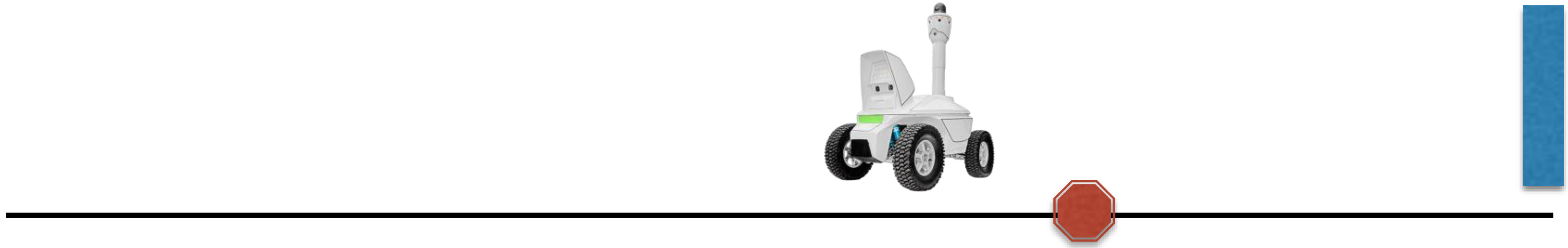


error=-2
speed=-20

Now the value is negative, and big, so the robot starts backing up at high speed

What if Kp is too large?

Kp = 10



error=2
speed=20

Now the value is big and positive again, so the robot starts driving forwards fast

Finding the right value

- Keep increasing Kp until the system oscillates then back it down a little

- There are other techniques, look online at PID control

Adding Proportional Control


```
void operatorControl() {
sonar = ultrasonicInit(9, 8);
int Kp=2;
int setPoint=10;
ultrasonicGet(sonar);
delay(1000);
while(1){
    int error=ultrasonicGet(sonar)-setPoint;
    driveWheels(Kp*error);
    delay(50);
}
}
```

Compute the distance from the set point (error)

Drive at a speed proportional to the set point