WPI

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

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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

```
Start driving forward

Wait 2 seconds
Turn for 1000ms
```

CODE

```
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

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

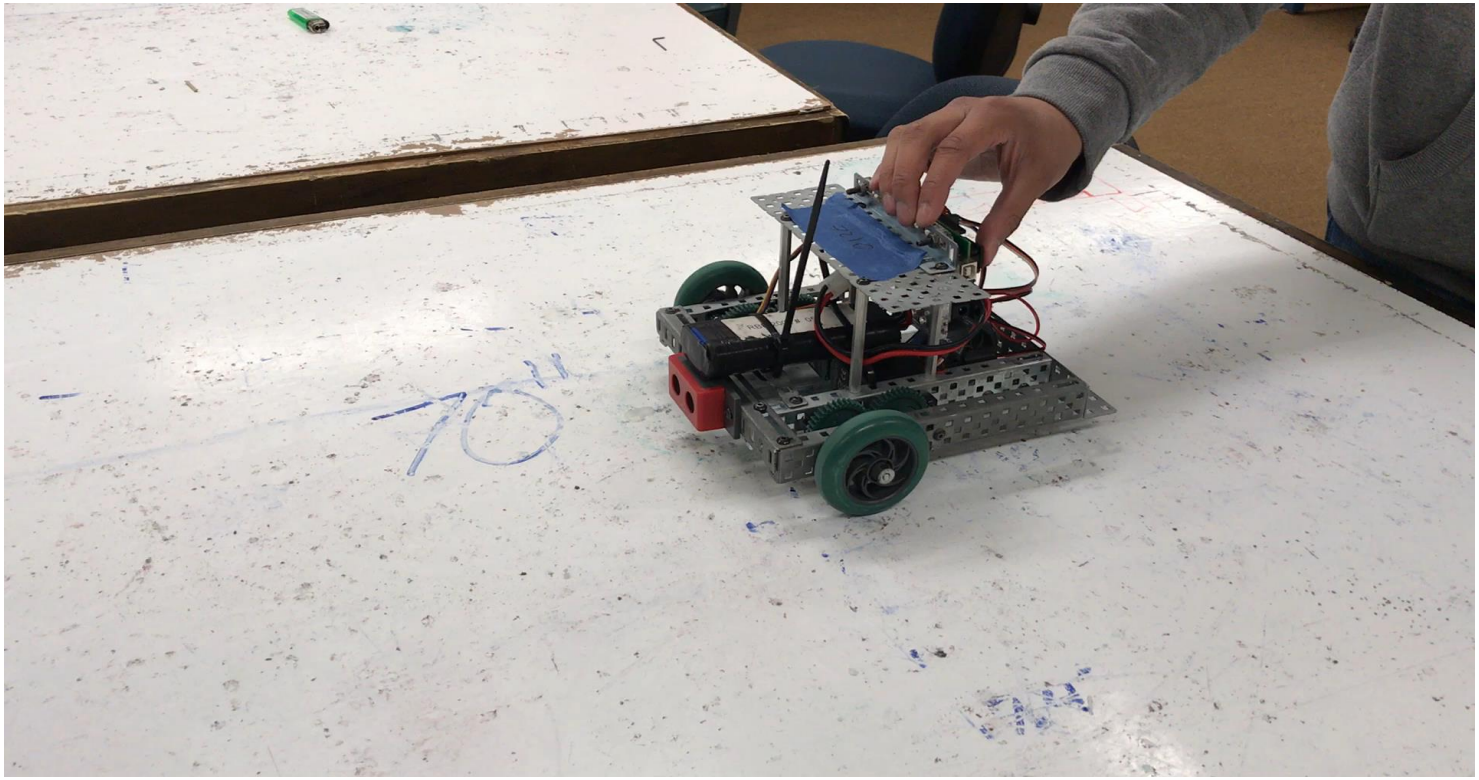
- For the program today, we created these functions:

```
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

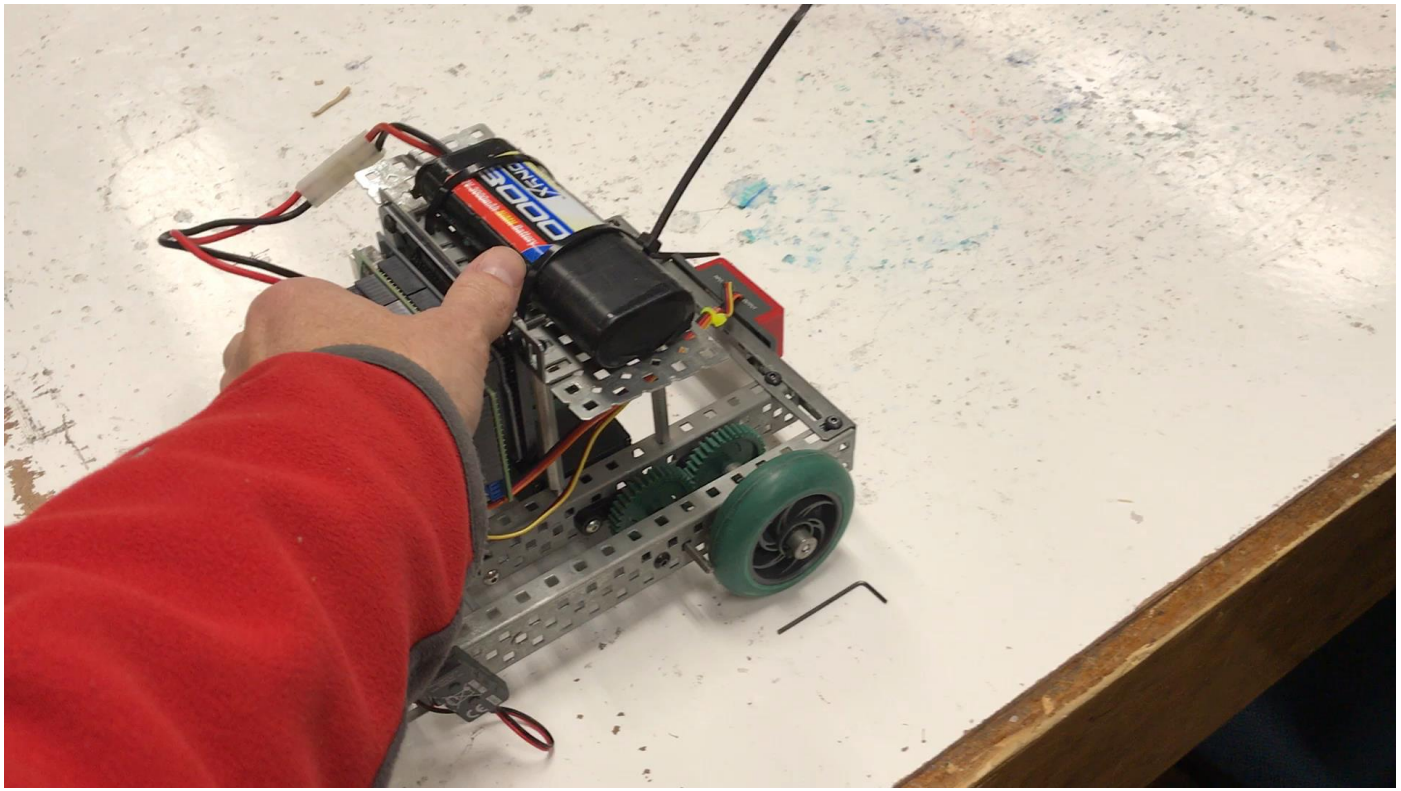

```
void driveForward(int time){
        motorSet(1,60);                 Set motors to drive forward
        motorSet(10,-60);               for "time"
        delay(time);
        motorStopAll();
 }
  void turnRight(int time){
        motorSet(1,60);                 Set motors to turn for
        motorSet(10,60);                specified "time"
        delay(time);
        motorStopAll();
  }
void operatorControl() {
        while (1) {                     Continuous loop of
                driveForward(1000);     driving x millisec
                delay(500);             pause x millisec
                turnRight(500);         turning x millisec
                delay(500);             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

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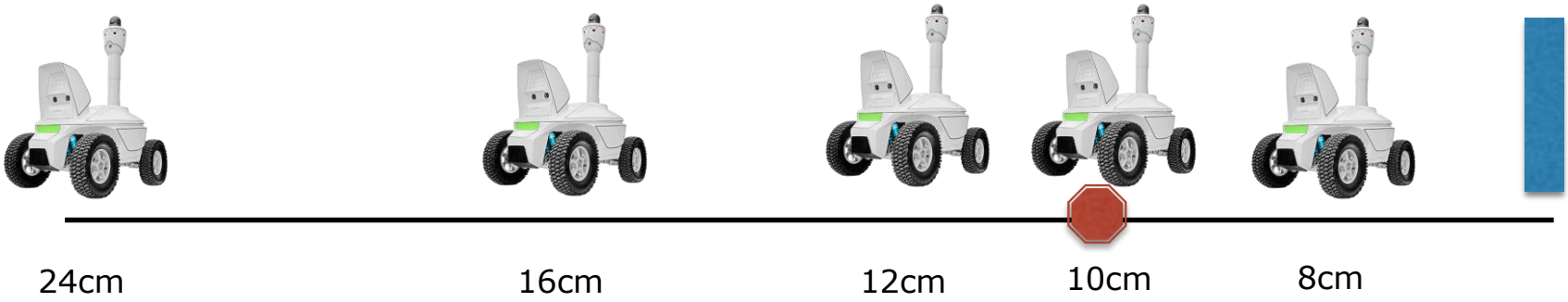
We want the robot to stop 10cm from the wall so the *target distance* or **set point** is 10

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

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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

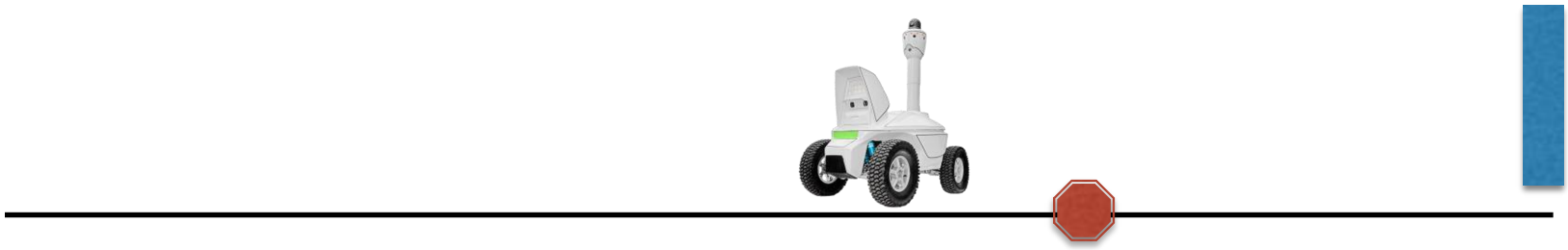
What if Kp is too small?

Kp = 1

error=3
speed=3

What if Kp is too small?

Kp = 1

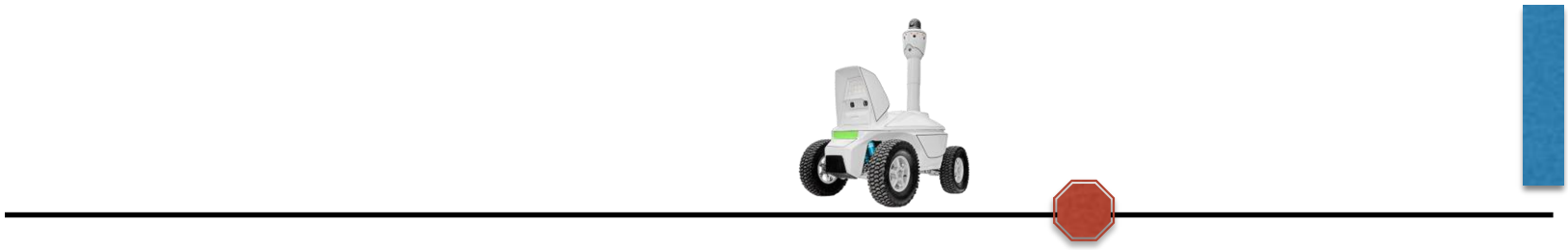


error=2
speed=2

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

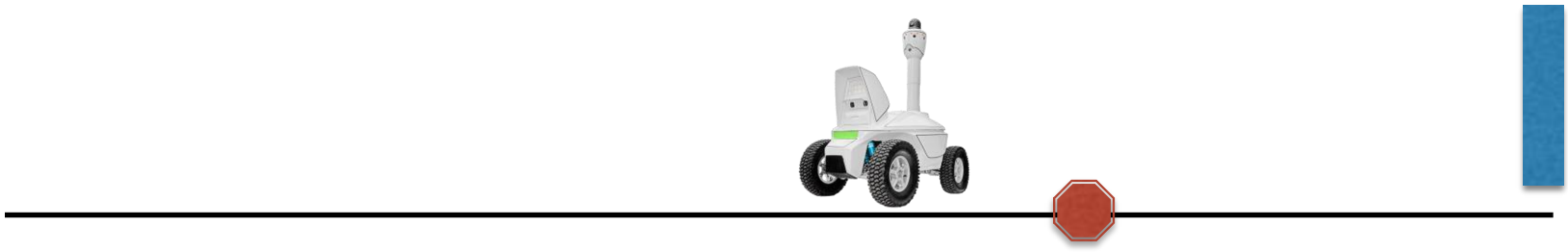
What if Kp is too large?

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?

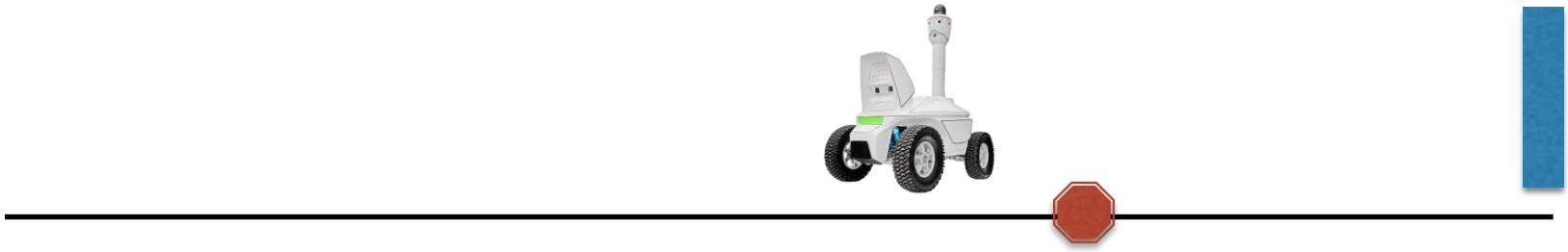
Kp = 10

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