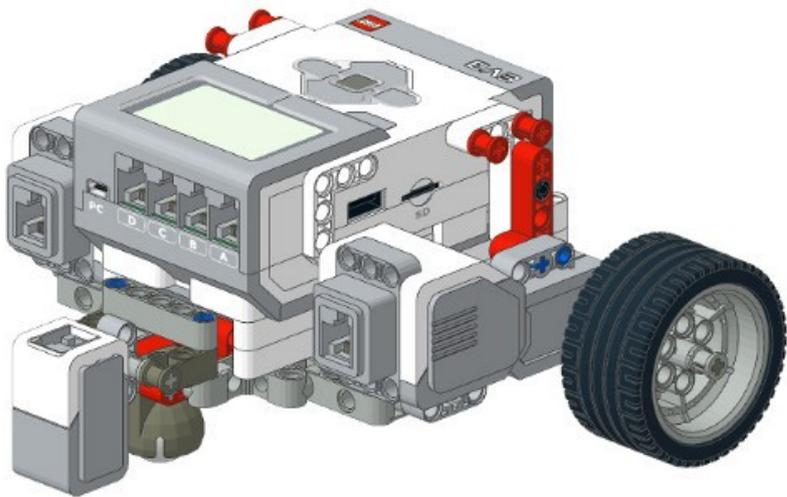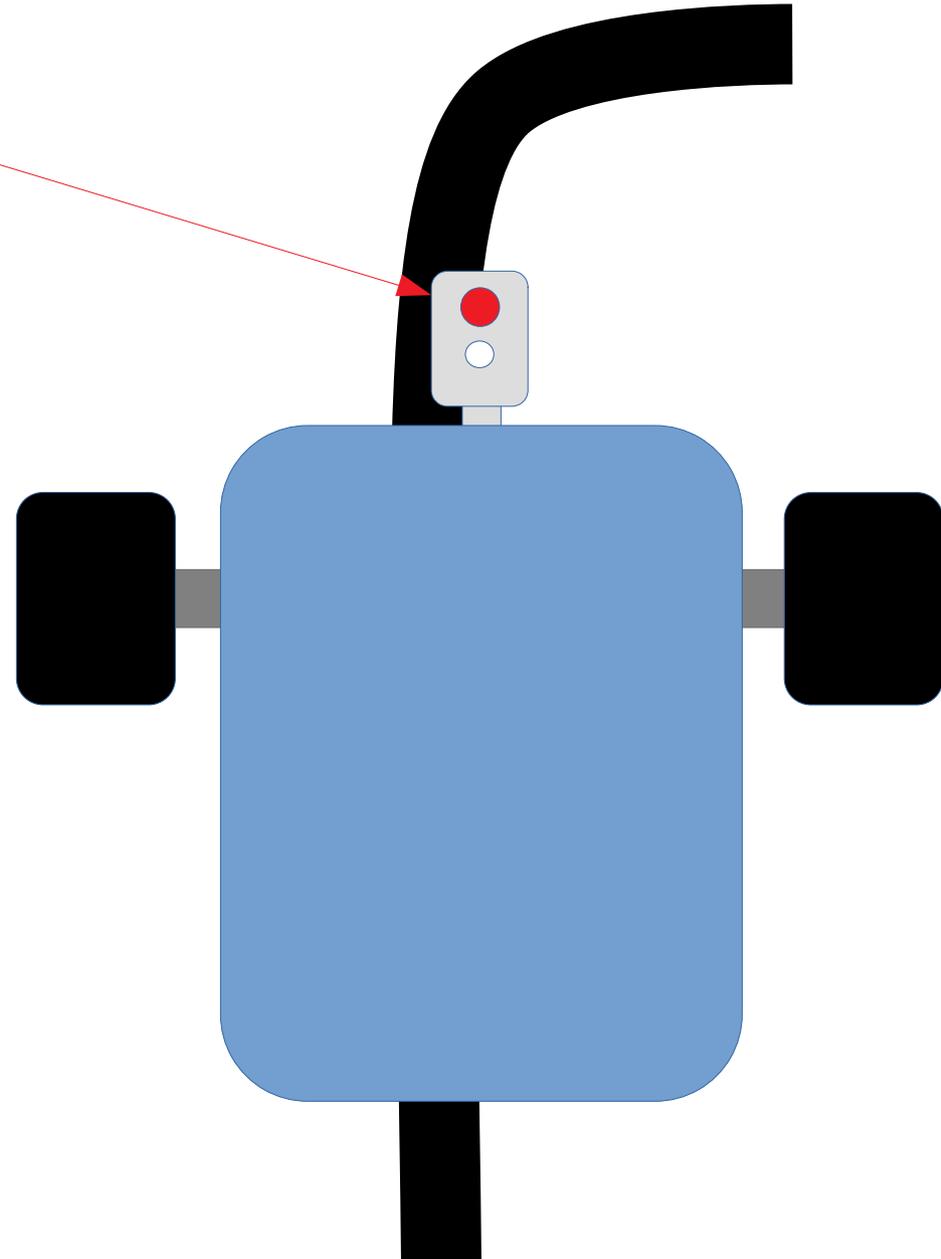# A POSTERIORI

Play · Experience · Learn

SINGLE SENSOR LINE FOLLOWER
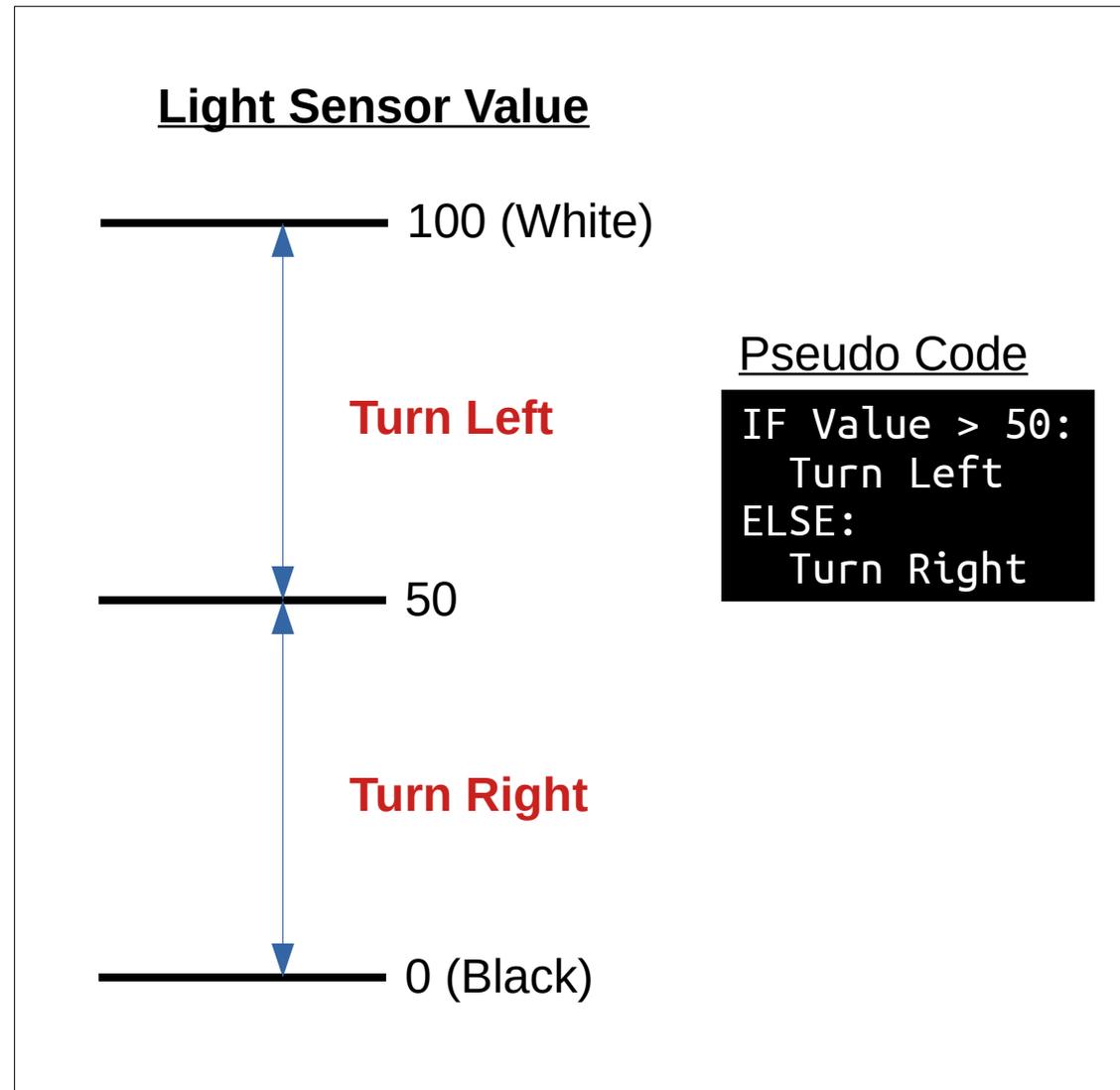
One Sensor Line Following

- Sensor on **<u>edge</u>** of line

- If sensor is reading…

  - White: Robot is too far right and needs to turn left

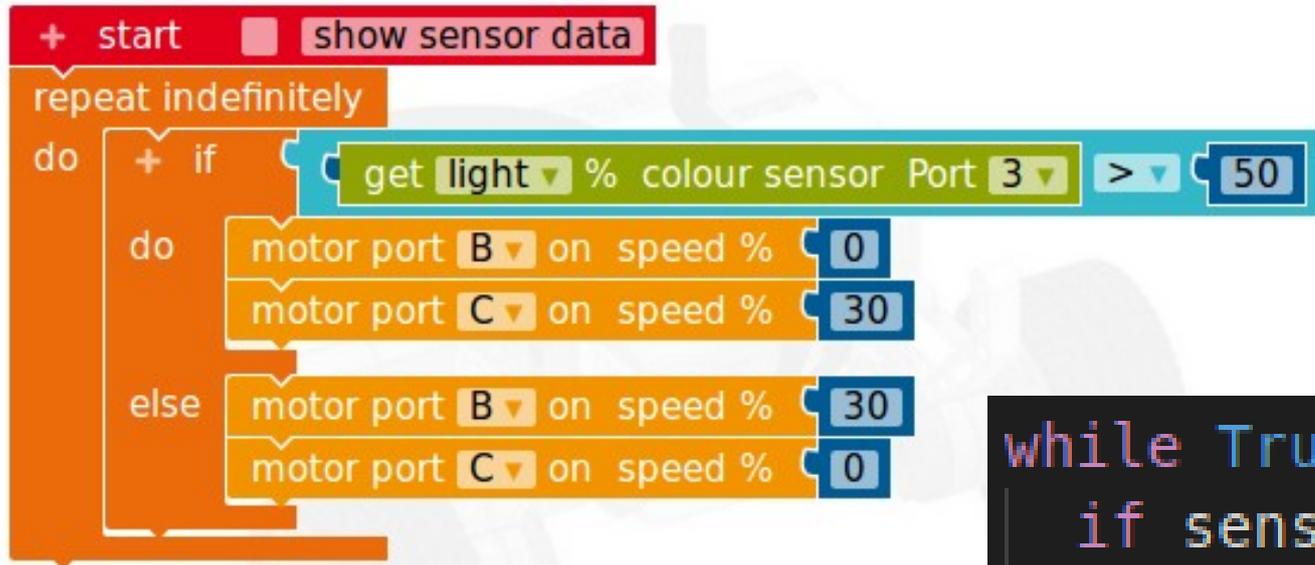 - Black: Robot is too far left and needs to turn right

2 States Algorithm

- Loops forever

- Switch monitors reflected light
  - White (>50): Turn Left
  - Black (<50): Turn Right

- Robot "wiggles" left and right

Light Sensor Value

—————— 100 (White)

Turn Left

—————— 50

Turn Right

—————— 0 (Black)

Pseudo Code

```
IF Value > 50:
    Turn Left
ELSE:
    Turn Right
```

2 States Algorithm


```
start  ☐  show sensor data
repeat indefinitely
do    + if   get light % colour sensor Port 3 > 50
      do   motor port B on speed % 0
           motor port C on speed % 30

      else motor port B on speed % 30
           motor port C on speed % 0
```

```python
while True:
    if sensor.value > 50:
        lMotor.speed_sp = 0
        rMotor.speed_sp = 300
    else:
        lMotor.speed_sp = 300
        rMotor.speed_sp = 0
    lMotor.run_forever()
    rMotor.run_forever()
```
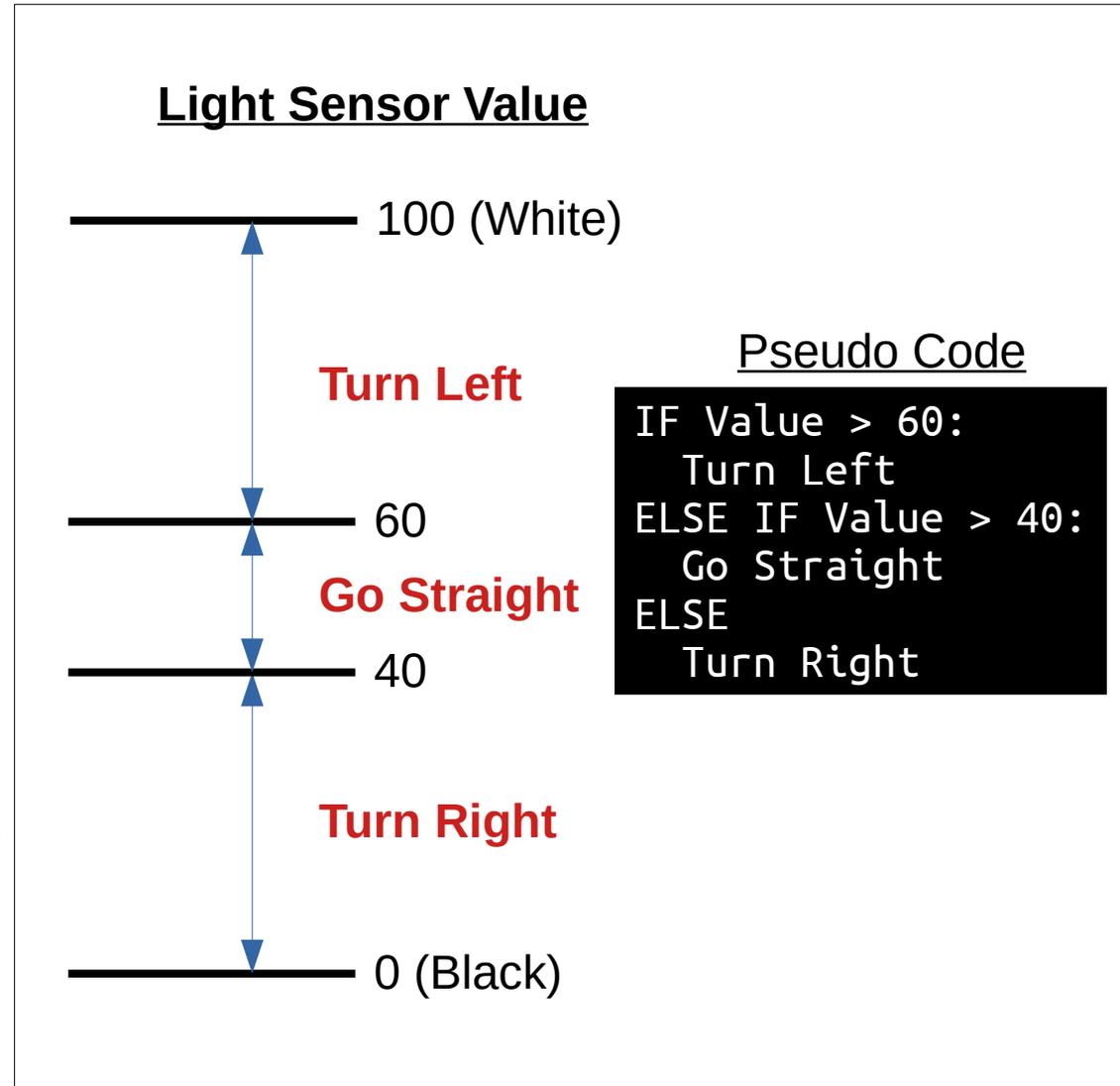
Initialization of motors and sensor not shown here.

Common Problems

- Problem:
  - Movement is slow and jerky
- Why?:
  - Robot ONLY move left and right. It never goes straight.

3 States Algorithm

- Check for **Black**, **White**, and **Grey**
  - White (>60): Turn Left
  - Black (<40): Turn Right
  - Grey (Between 40 to 60): Go Straight

- Robot runs smoother

Light Sensor Value

——————— 100 (White)

Turn Left

——————— 60

Go Straight

——————— 40

Turn Right

——————— 0 (Black)

Pseudo Code

```
IF Value > 60:
   Turn Left
ELSE IF Value > 40:
   Go Straight
ELSE
   Turn Right
```

3 States Algorithm


```python
while True:
    if sensor.value > 60:
        lMotor.speed_sp = 0
        rMotor.speed_sp = 300
    elif sensor.value > 40:
        lMotor.speed_sp = 300
        rMotor.speed_sp = 300
    else:
        lMotor.speed_sp = 300
        rMotor.speed_sp = 0
    lMotor.run_forever()
    rMotor.run_forever()
```
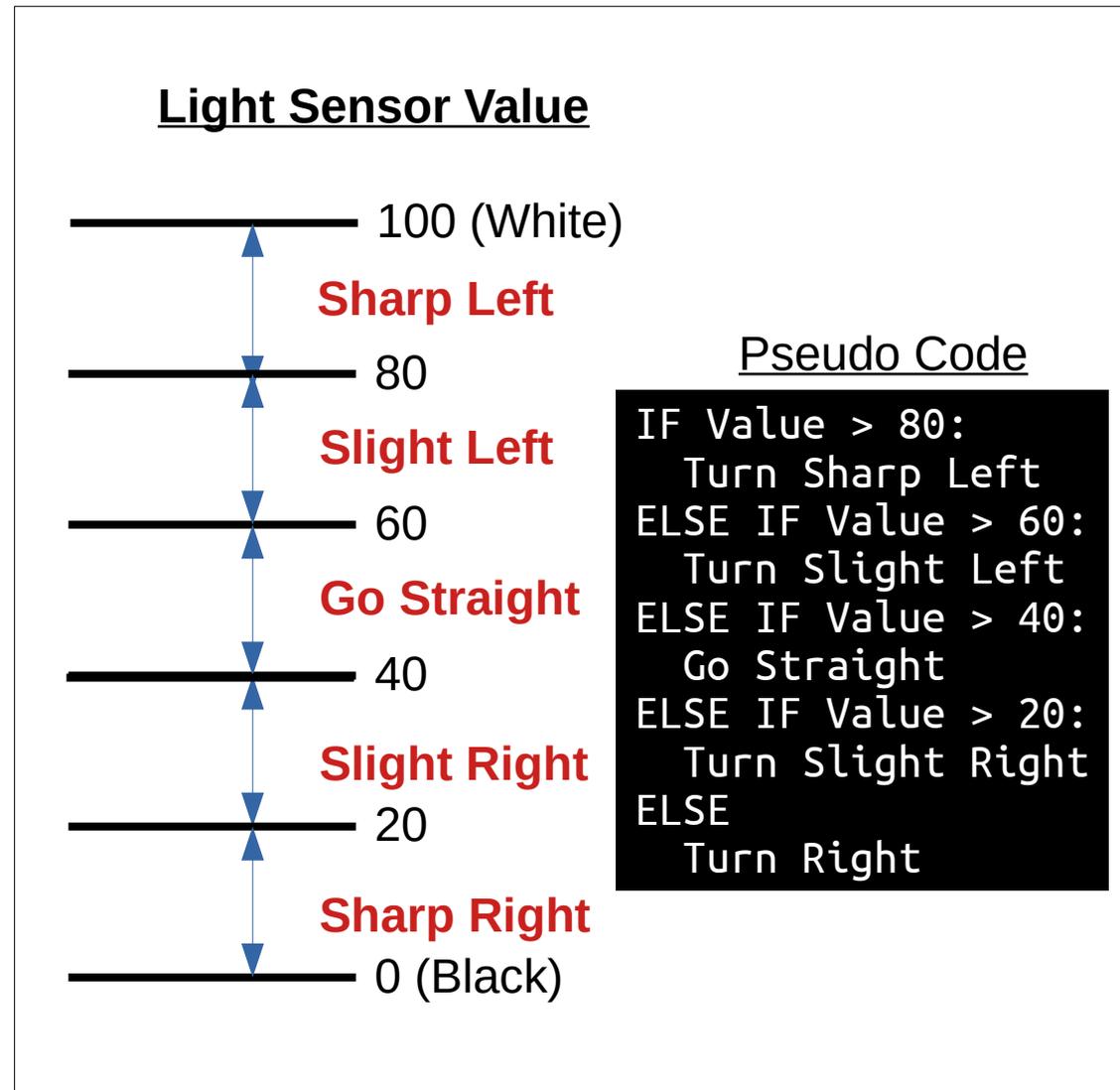
Common Problems

- Problem:
  - Better than 2 states, but still a little jerky
  - May be good enough
- Can we do better?

5 States Algorithm

- Take it a step further by checking for 5 levels of light sensor value:

- Robot runs even smoother than 3 states

Light Sensor Value

————— 100 (White)

Sharp Left

————— 80

Slight Left

————— 60

Go Straight

————— 40

Slight Right

————— 20

Sharp Right

————— 0 (Black)

Pseudo Code

```
IF Value > 80:
    Turn Sharp Left
ELSE IF Value > 60:
    Turn Slight Left
ELSE IF Value > 40:
    Go Straight
ELSE IF Value > 20:
    Turn Slight Right
ELSE
    Turn Right
```

5 States Algorithm
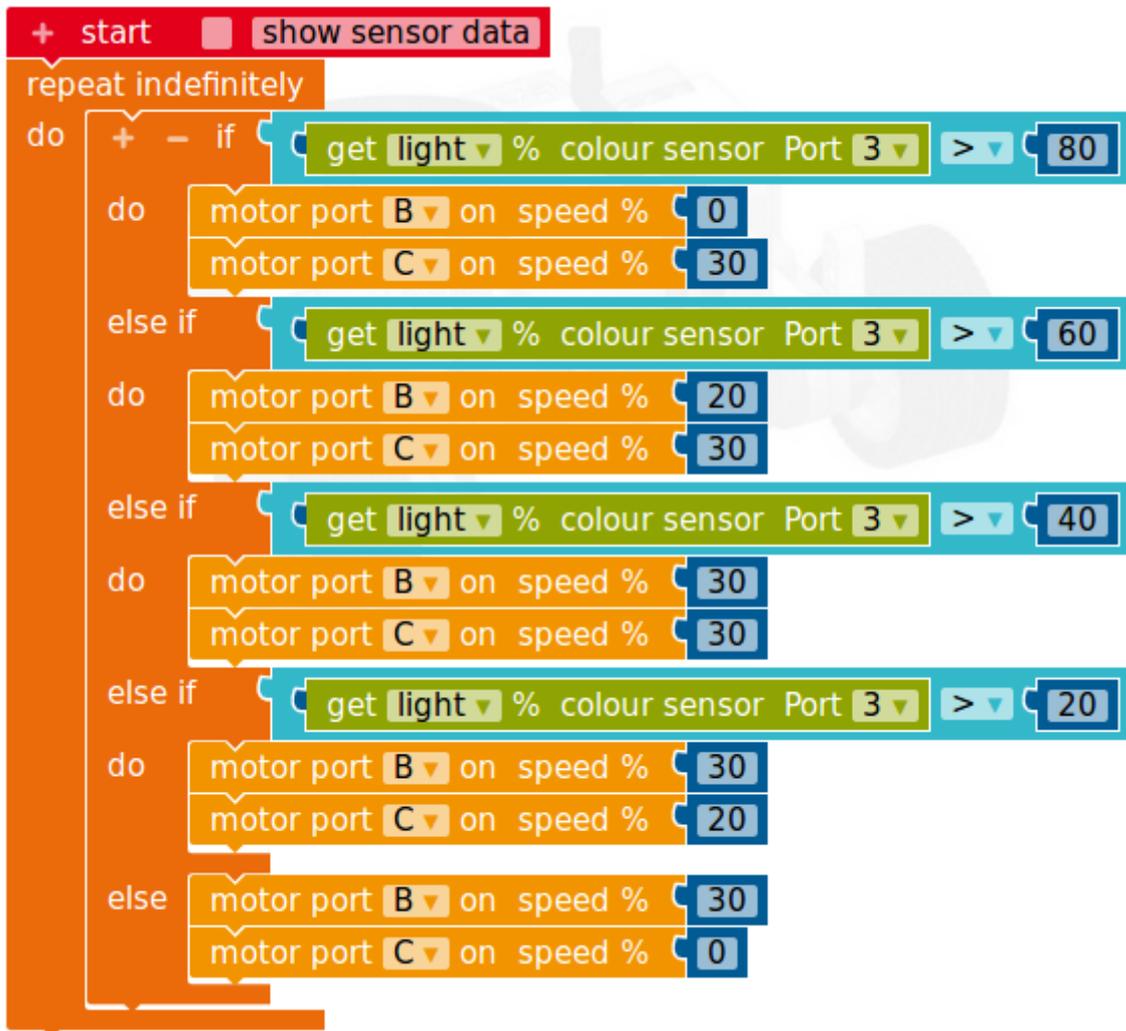

```python
while True:
    if sensor.value > 80:
        lMotor.speed_sp = 0
        rMotor.speed_sp = 300
    elif sensor.value > 60:
        lMotor.speed_sp = 200
        rMotor.speed_sp = 300
    elif sensor.value > 40:
        lMotor.speed_sp = 300
        rMotor.speed_sp = 300
    elif sensor.value > 20:
        lMotor.speed_sp = 300
        rMotor.speed_sp = 200
    else:
        lMotor.speed_sp = 300
        rMotor.speed_sp = 0
    lMotor.run_forever()
    rMotor.run_forever()
```
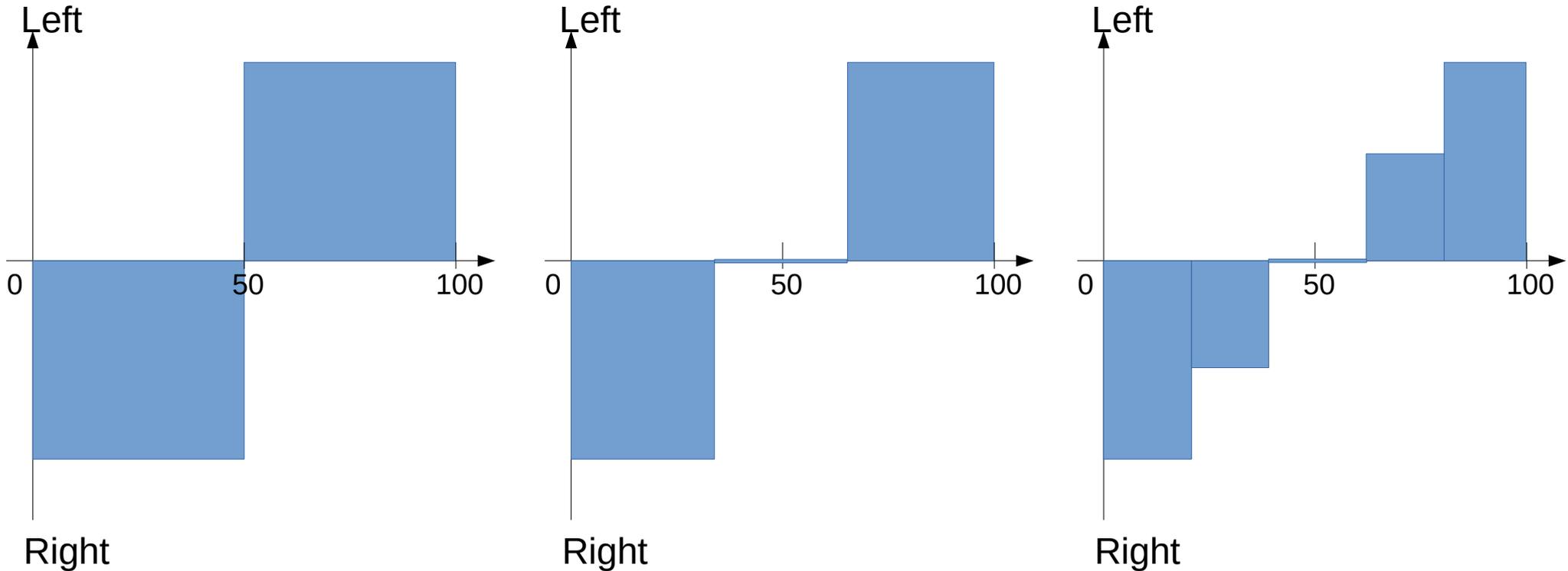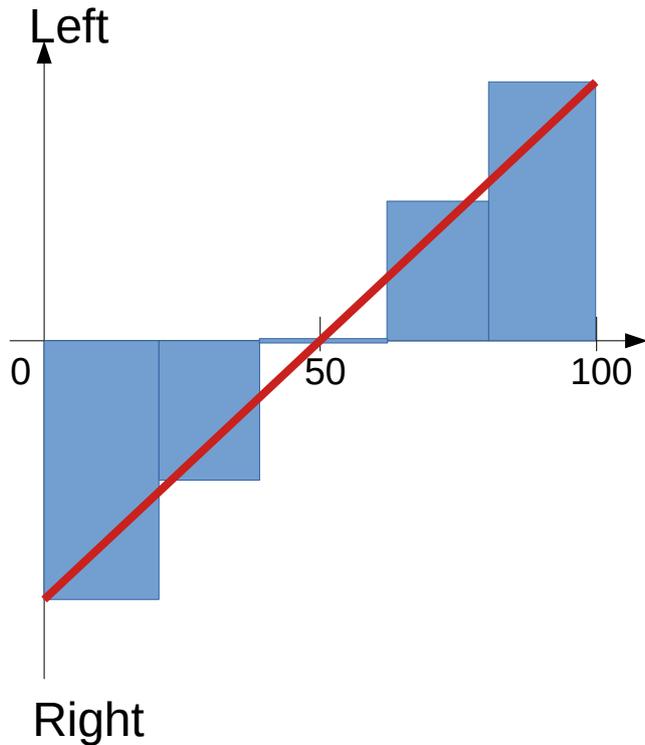
Comparison of 2, 3, 5 states
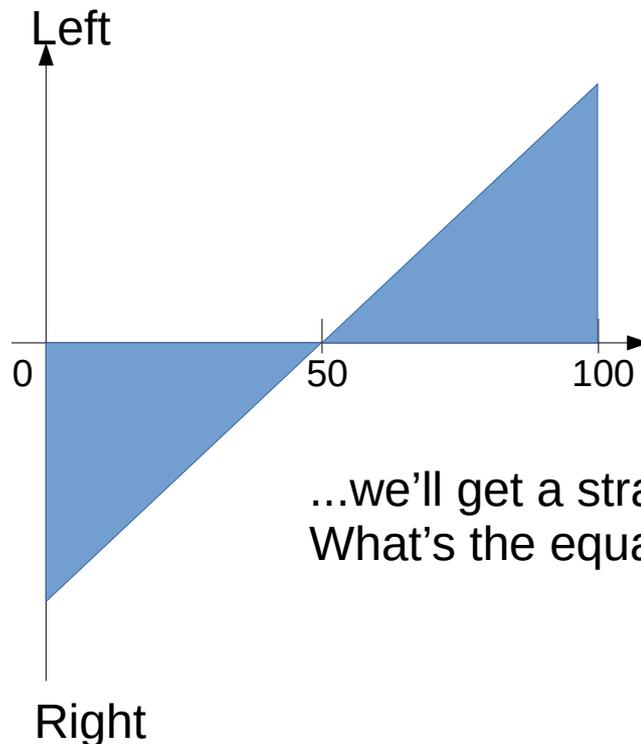

What happens if I increase the number of states?
(eg. 7 states, 9 states, 11 states)

Increasing number of states

Left

0   50   100

Right

As we increase the number of states, the diagram starts to look more like a straight line.

What if we have an infinite number of states?

Left

0   50   100

Right

...we'll get a straight line!
What's the equation of the line?

Equation of line

- Standard form

  $y = mx + c$

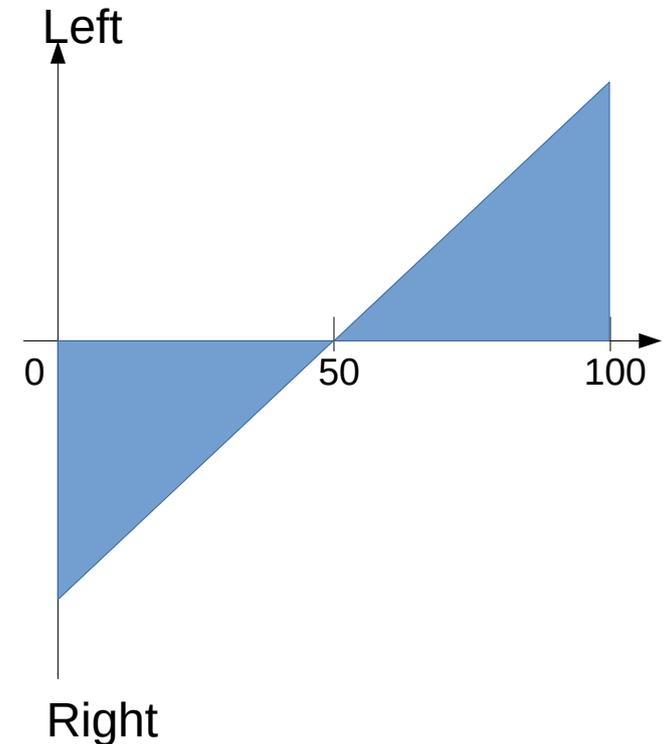- Crosses x axis at x = 50, y = 0

  $0 = m(50) + c$

  $m = -c / 50$

- Substitute and rearrange

  $y = (-c / 50)x + c$

  $y = -c (x / 50 – 1)$

  $y = -c / 50 (x – 50)$

  $y = k (x – 50)$, where k = -c / 50

Equation of line
(Engineering Style)

Gain

Sensor value

Midpoint

Add to right motor

$$K_p \times (S - 50)$$

Error

Correction

Subtract from left motor
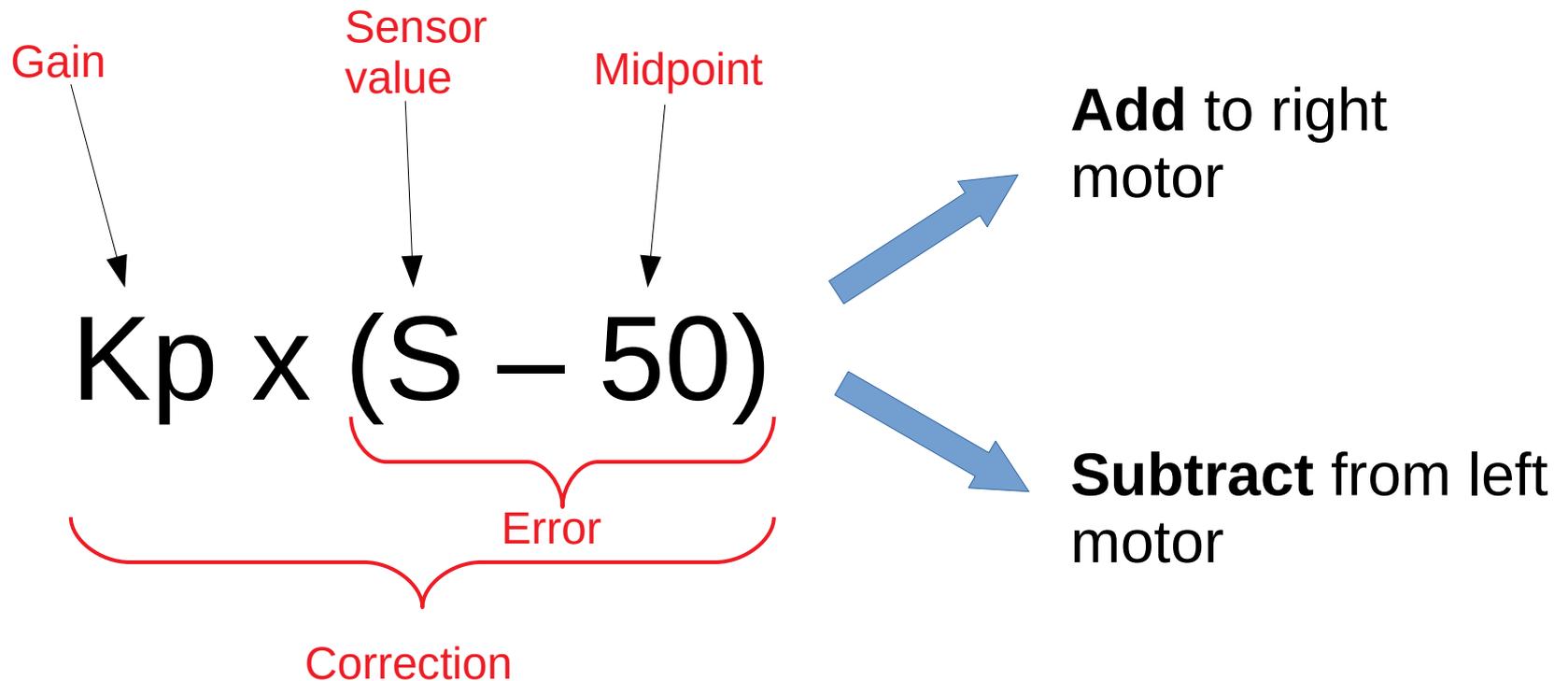
These are standard engineering terminology. Professional engineers uses these terms to make themselves sound smarter. You should do the same!

* The "p" in "Kp" stands for proportional. In a full PID (Proportional, Integral, Derivative) control, you will also have an "Ki" and "Kd".

Proportional Control

Speeds up at sharp turns...

```python
while True:
    error = sensor.value - 50
    correction = 2 * sensor.value
    lMotor.speed_sp = 300 + correction
    rMotor.speed_sp = 300 - correction
    lMotor.run_forever()
    rMotor.run_forever()
```

Using single motors

```
+ start     ☐  show sensor data
  –  variable error : Number ▾  ←  0
  –  variable correction : Number ▾  ←  0

repeat indefinitely
do    set error ▾ to    get light ▾ % colour sensor  Port 3 ▾  - ▾  50
      set correction ▾ to    0.2  x ▾  error ▾
      motor port B ▾ on  speed %    30  + ▾  correction ▾
      motor port C ▾ on  speed %    30  - ▾  correction ▾
```

```python
while True:
    error = sensor.value - 50
    correction = 1 * error
    steering_drive.on(correction, SpeedPercent(30))
```

...use this if possible!

Using move steering

Proportional Control

- Changing Gain:
  - Increase: Turns more sharply, may wobble
  - Decrease: Tuns more smoothly, may fail at sharp turns
- Is proportional control the best solution?
  - Depends. Proportional controls have a **straight line** response, and you **can only tune the Gain** (gradient of the line)
  - High gain may wobble too much, low gain may fail at sharp turns. **Depending on the map and robot, there may not exist a Gain value that is both smooth and can handle sharp turns.**

Proportional Control

- Test to find the best gain!
  - Suggest testing within the range of 0.1 to 4
- Possibilities to explore:
  - Non-proportional control (ie. not a straight line eqn).
    - Will a quadratic eqn work? (spoiler: No it won't, but why not?)
    - What about a cubic eqn?
  - Add in Integral and Derivative terms to make it a PID controller

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