ADVANCED EV3
PROGRAMMING LESSON

Line Followers: Basic to PID

By Sanjay and Arvind Seshan

Lesson Objectives

- Evaluate and compare different line followers

- Prerequisites: Complete all Line Follower lessons on EV3Lessons.com, Calibration
- Videos will not play in PDF

Which Program Works Best for Which Situation?

Simple Line Follower

- Most basic line follower
- Wiggles a lot due to sharp turns
- Good for rookie teams → need to know loops and switches

Smooth Line Follower

- Almost the same as simple
- Turns are less sharp
- Has trouble on sharp curves
- Good for rookie teams → need to know loops and switches

3-Stage Follower

- Best for straight lines
- Droids do not recommend this. Just learn the proportional line follower.
- Need to know nested switches

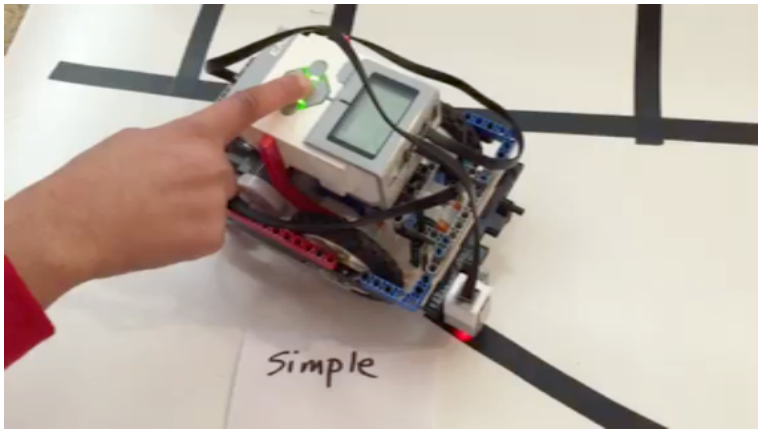
Proportional Follower

- Uses the "P" in PID
- Makes proportional turns
- Works well on both straight and curved lines
- Good for intermediate to advanced teams → need to know math blocks and data wires

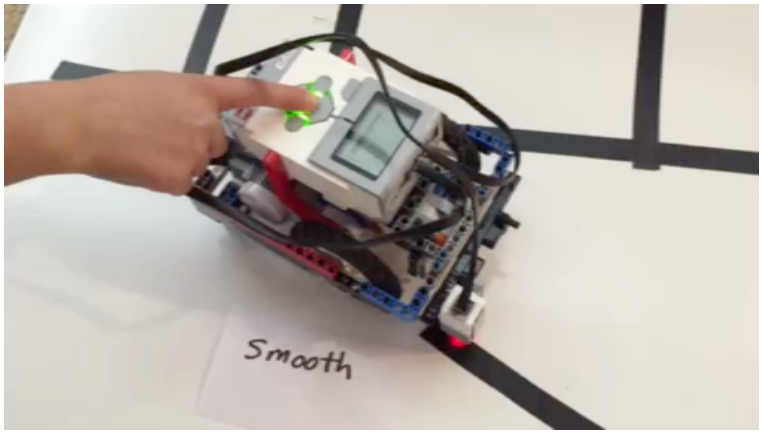
Watch the videos on the next 2 slides to see all four.

Curved Line: Watch Videos

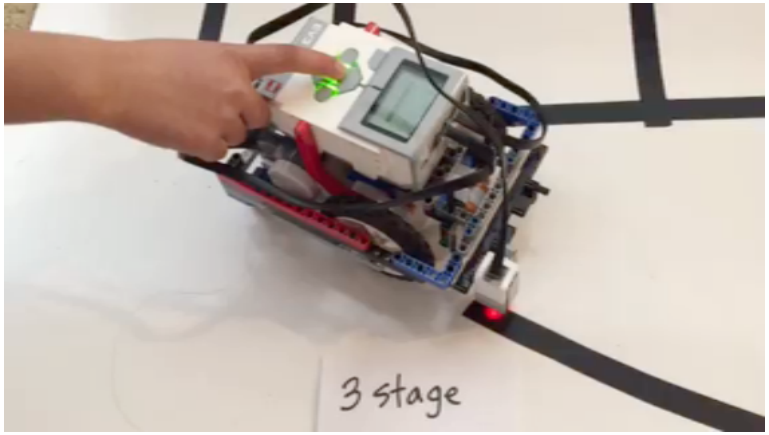
Simple Line Follower



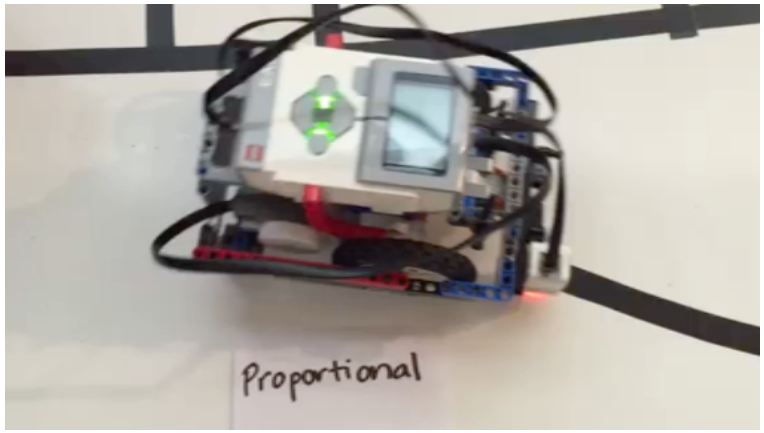
Smooth Line Follower



3-Stage Follower

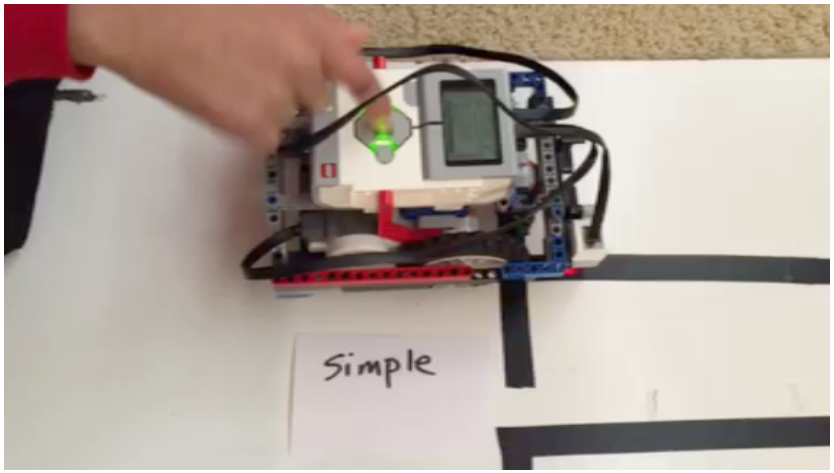


Proportional Follower

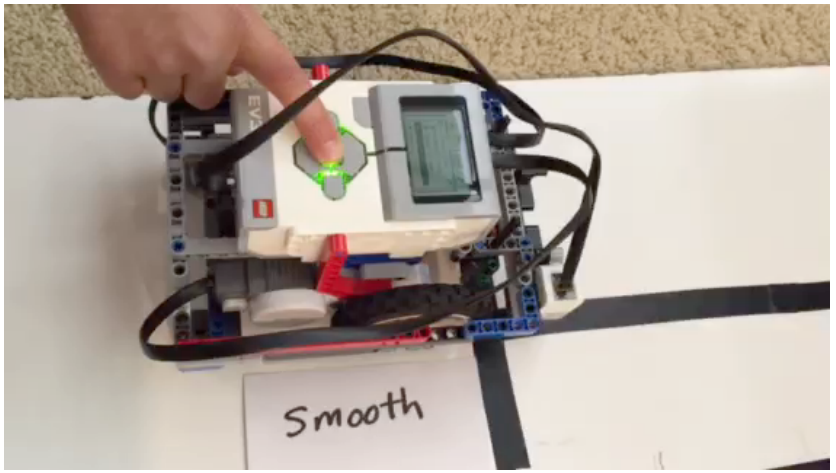


Straight Line: Watch Videos

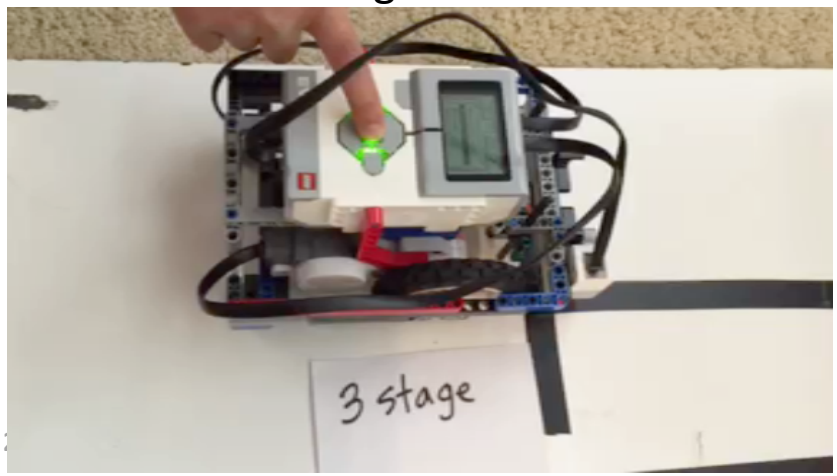
Simple Line Follower



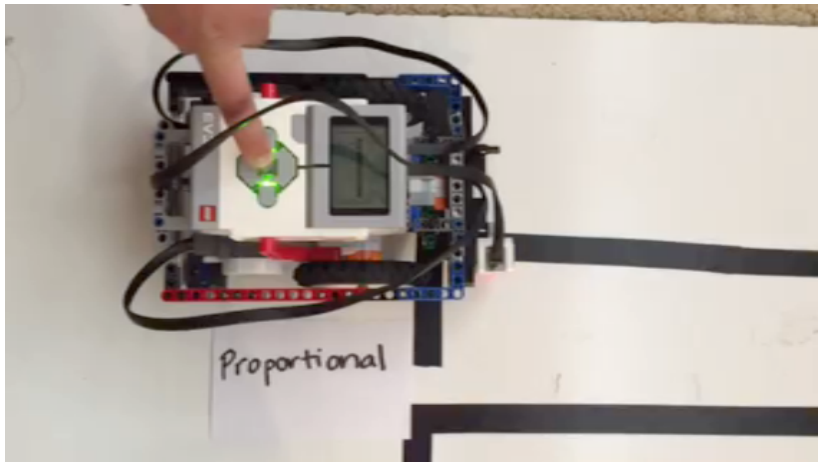
Smooth Line Follower



3-Stage Follower

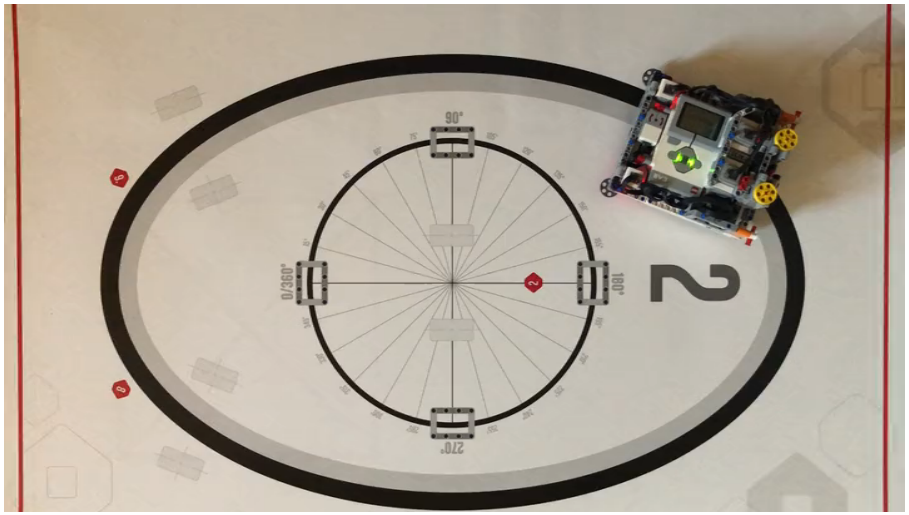


Proportional Follower

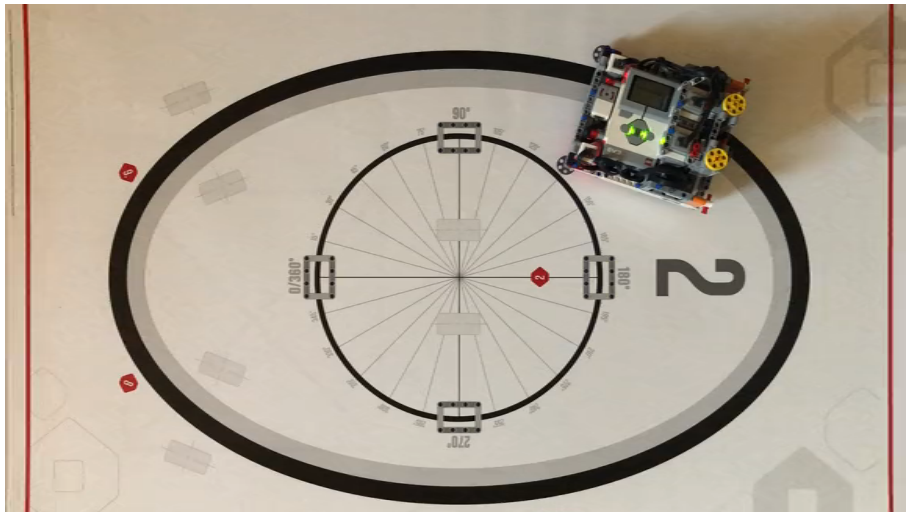


Watch Videos

Proportional Follower



PID Follower



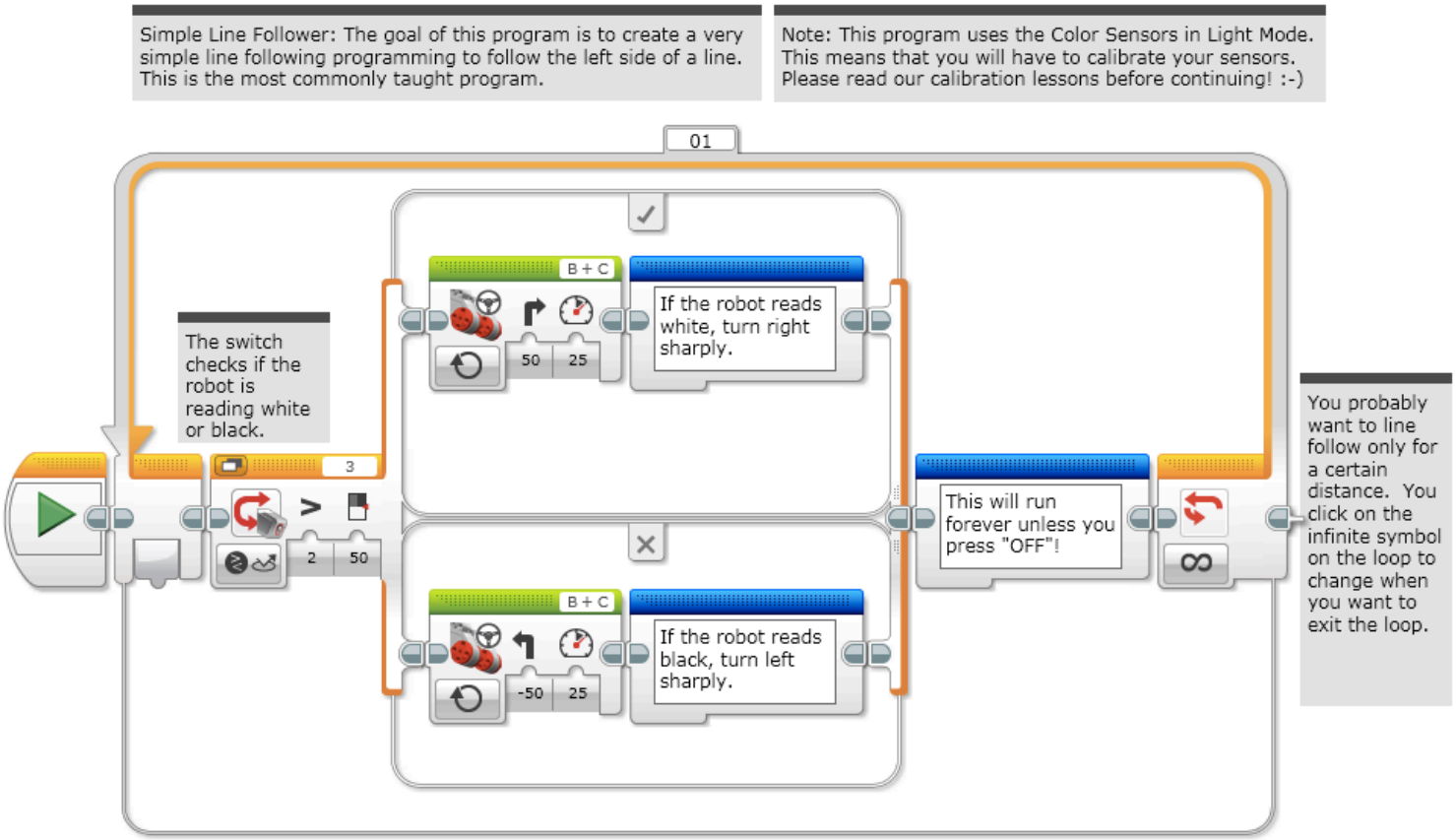
3 Line Follower Challenges

- Challenge 1: Can you write a simple line follower? Hint: Review Beginner: Basic Line Follower lesson
- Challenge 2: Can you write a smoother line follower? Hint: Change how sharp the turns are in a simple line follower.
- Challenge 3: Can you write a three-stage line follower where the robot moves different 3 different ways (left, right or straight) based on the reading from the color sensor?

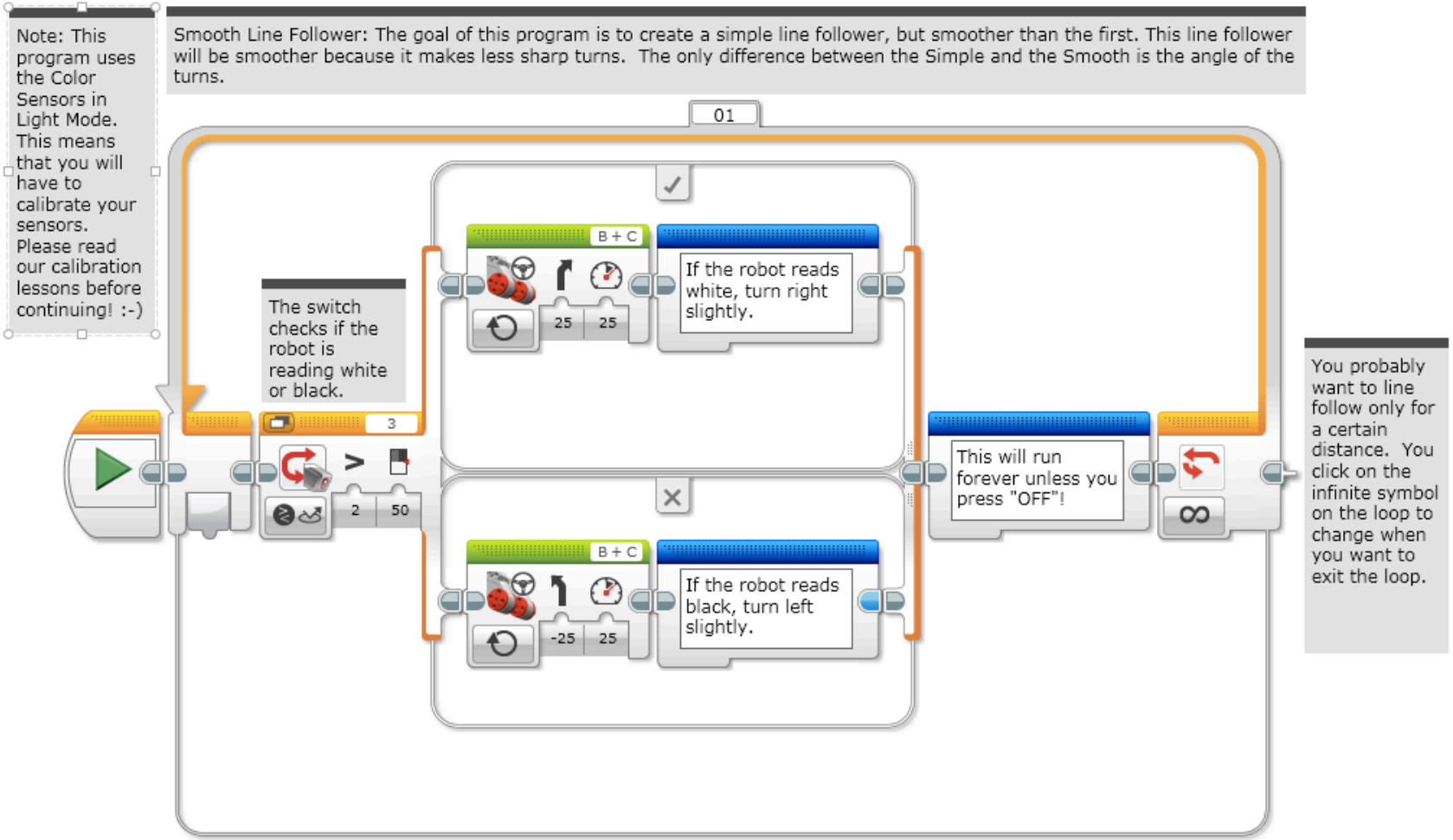
A Note About Our Solutions

- CALIBRATE:
  - The programs use the EV3 Color Sensor in Light Sensor mode
  - You will have to calibrate your sensors.
  - Please refer to Intermediate: Color Sensor Calibration Lesson
- PORTS:
  - The Color Sensor is connected to Port 3.
  - Please change this for your robot.
- WHICH SIDE OF THE LINE:
  - Please take note of which side of the line the code is written for

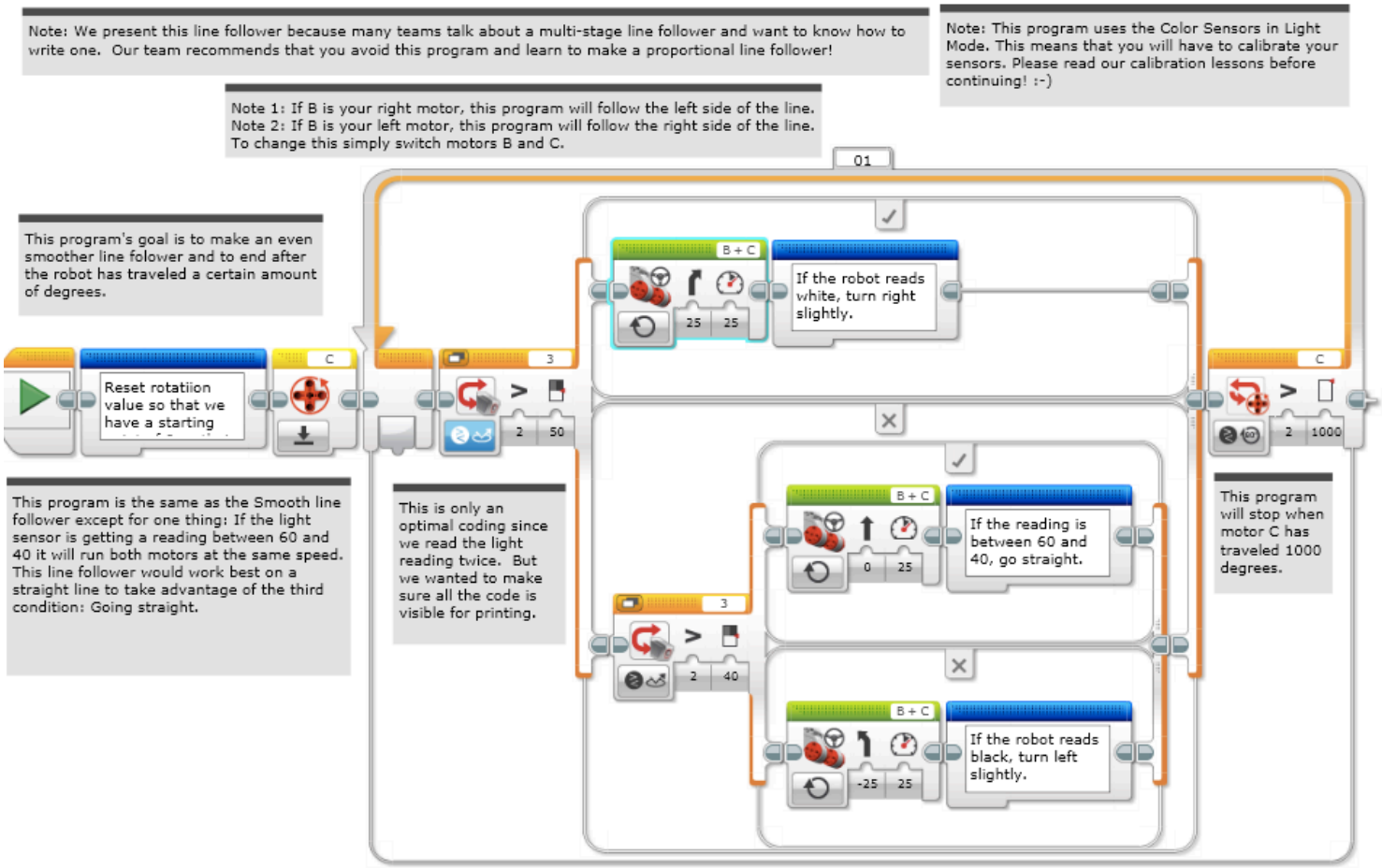
Simple Line Follower



Smooth Line Follower



Three-Stage Line Follower



Proportional Pseudocode

Can you write a proportional line follower that changes the angle of the turn depending on how far away from the line the robot is?

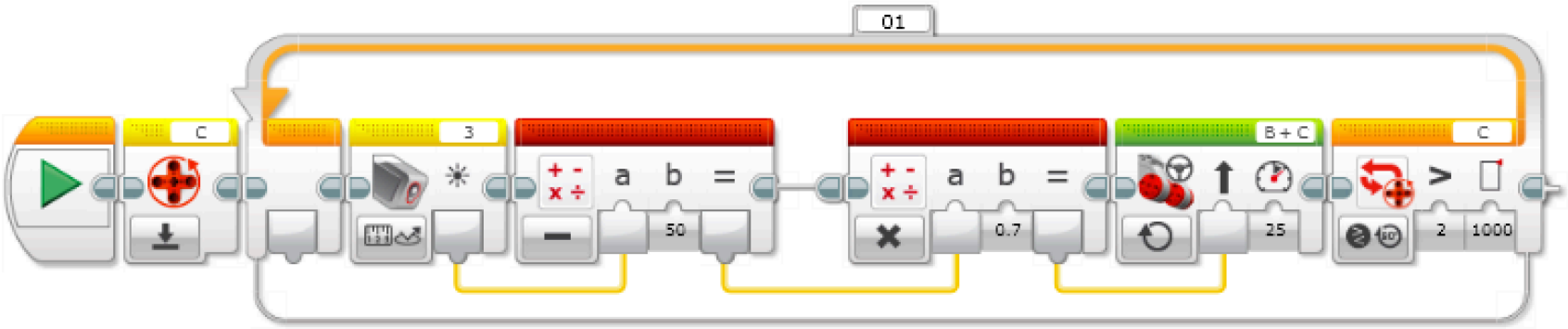
Pseudocode:

1. Reset the Rotation sensor (Only required for line following for a total distance)
2. Compute the error = Distance from line = (Light sensor reading – Target Reading)
3. Scale the error to determine a correction amount. Adjust your scaling factor to make you robot follow the line more smoothly.
4. Use the Correction value (computer in Step 3) to adjust the robot's turn towards the line.

Proportional Line Follower

Note: This program uses the color sensor in reflected light mode. You will need to calibrate your color sensor. If you do not know how to calibrate, please refer to our Calibration lesson.

Please refer to Proportional Control Lesson for more details



Reset the rotation sensor

Part 1: Compute the Error
Our goal is to stay at the edge of the line (light sensor = 50)

Part 2: Apply the correction
The error in part 1 is multiplied by a Constant of Proportionality (0.7). This will be different for each robot/application. See slides 9-11 to learn how to tune this number.

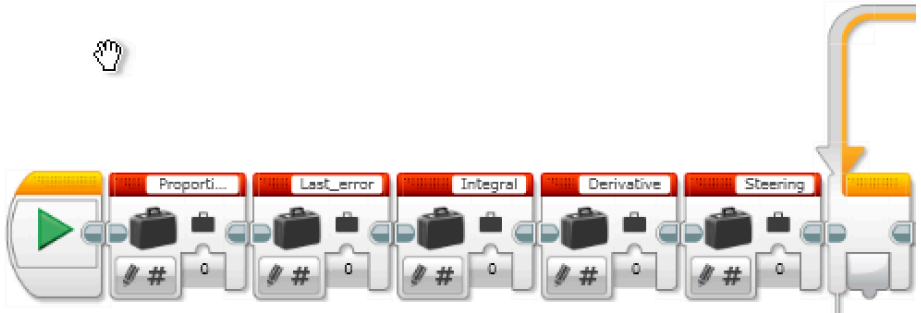
This line follower ends after 1000 degrees. Change this to suit your needs.

PID Pseudocode

1. Take a new light sensor reading
2. Compute the “error”
3. Scale error to determine contribution to steering update (proportional control)
4. Use error to update integral (sum of all past errors)
5. Scale integral to determine contribution to steering update (integral control)
6. Use error to update derivative (difference from last error)
7. Scale derivative to determine contribution to steering update (derivative control)
8. Combine P, I, and D feedback and steer robot

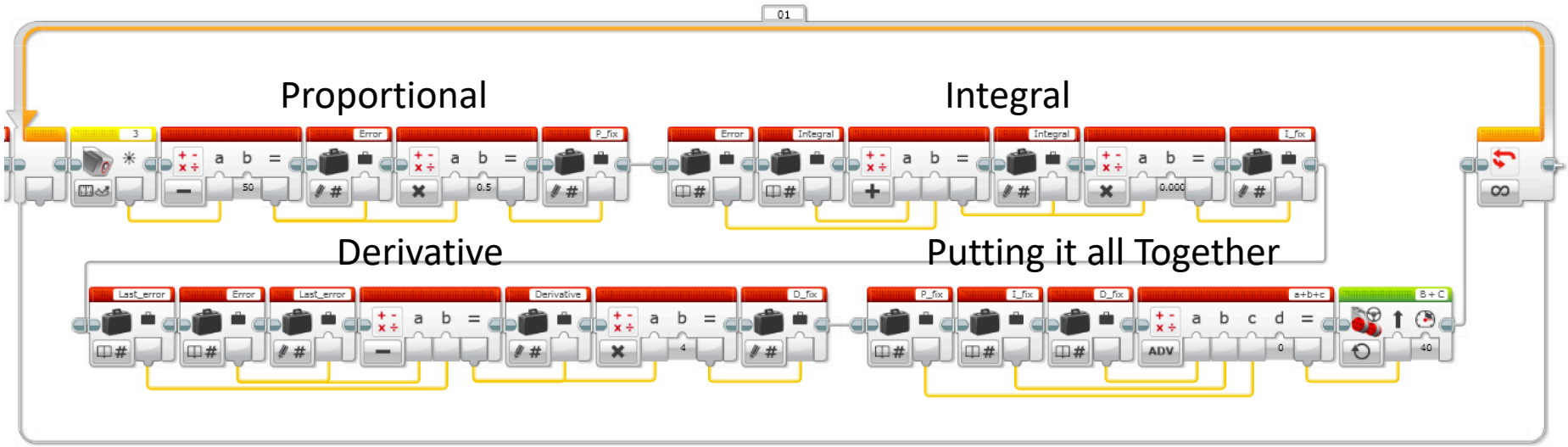
Full Code

Set up the 5 variables before the loop and initialize to 0



Code has been split for readability. Continues below.

Please refer to PID Lesson for more details.



Evaluating Line followers

Proportional

- Uses the “P” in PID
- Makes proportional turns
- Works well on both straight and curved lines
- Good for intermediate to advanced teams → need to know math blocks and data wires

PID

- It is better than proportional control on a very curved line, as the robot adapts to the curviness
- However, for FIRST LEGO League, which mostly has straight lines, proportional control can be sufficient

Credits

- This tutorial was created by Sanjay Seshan and Arvind Seshan
- More lessons at www.ev3lessons.com