RoboCup Rescue

Workshop

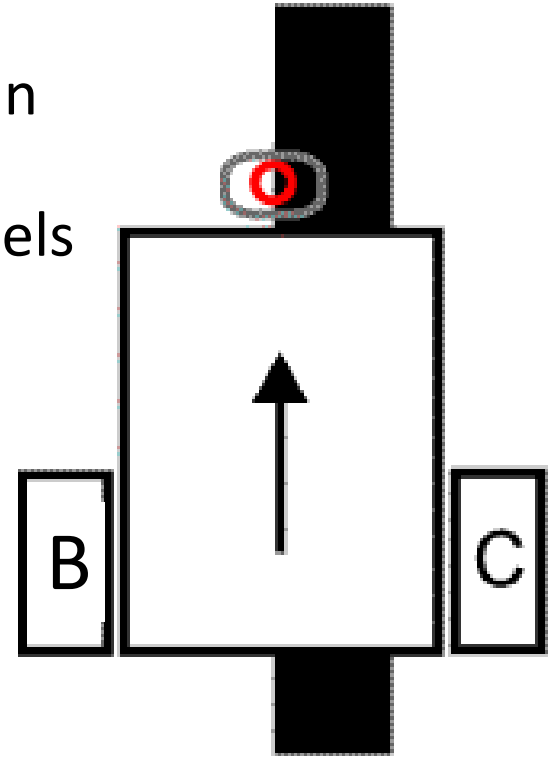
Part 3

modern teaching aids

Energizer

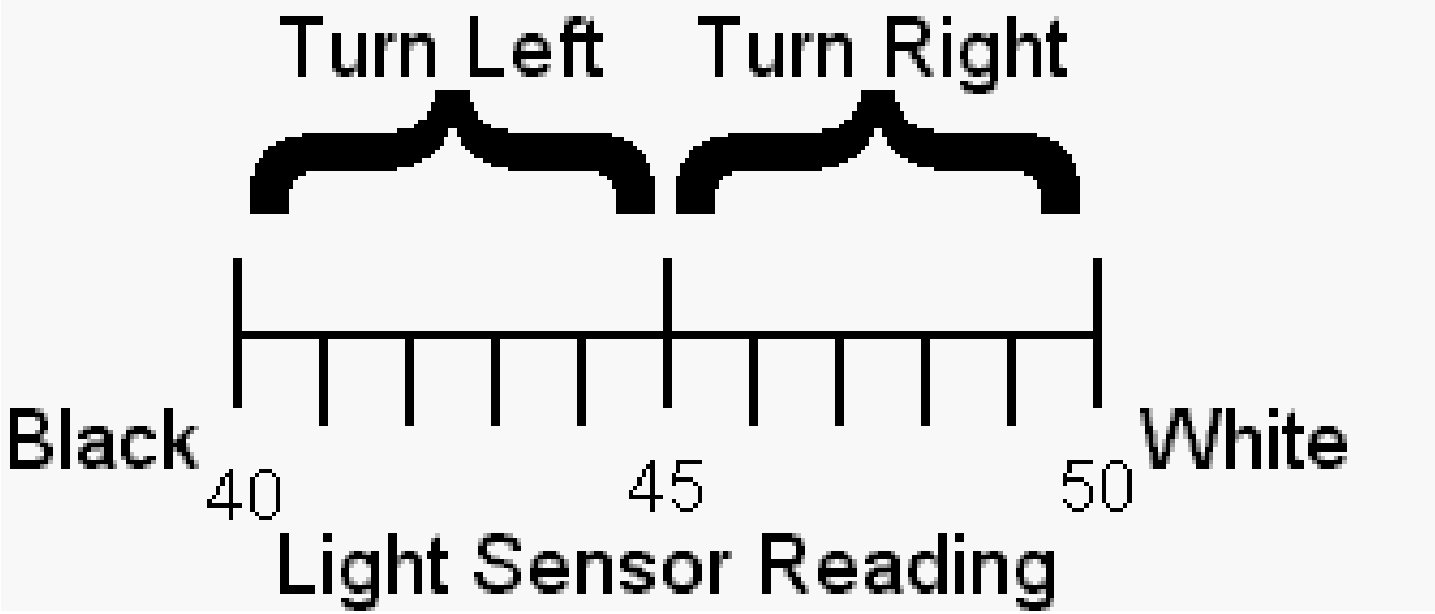
Advanced Line Following Algorithms

- Most Lego Line Following robots are of the Differential Steer type
- The geometry of Drive Wheels to Sensor varies from an equilateral triangle (as shown) to almost flat with the sensors just in front of the wheels
- Note: Each configuration will work as an effective Line Following robot, however, the most important consideration is the radius of the tightest curve on the course in relation to the position of the sensors and the inside pivot wheel!



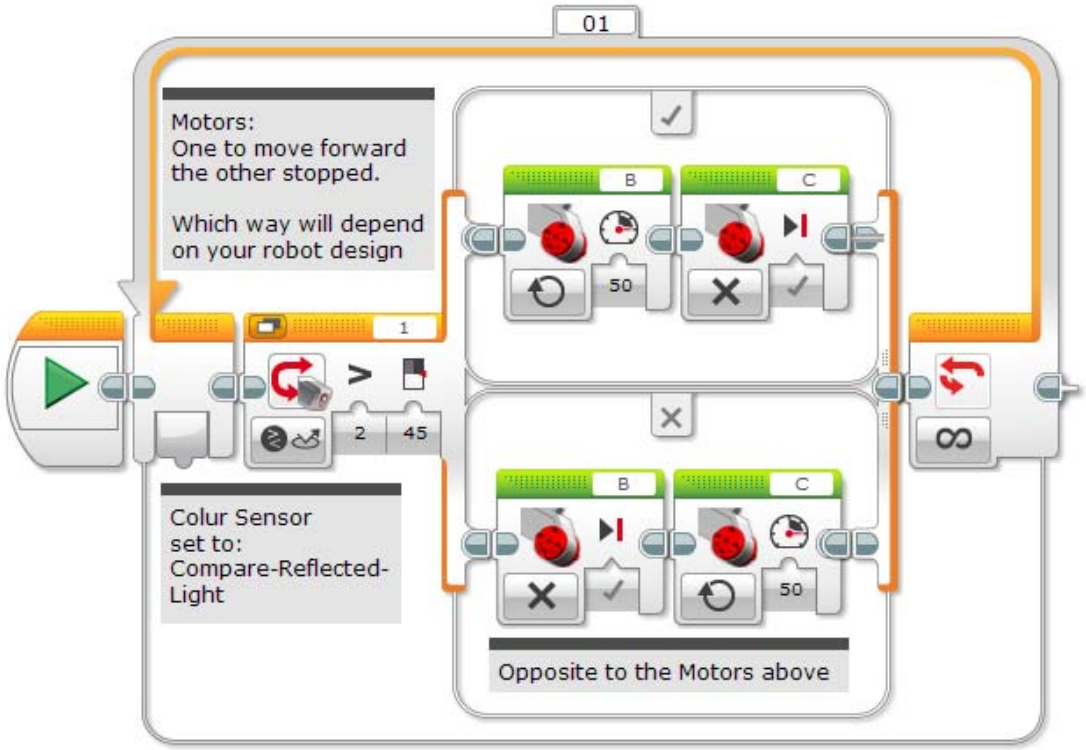
Simple Edge Follower

- Two Region Light Line
- Light Sensor reads 40 for Black, 50 for White



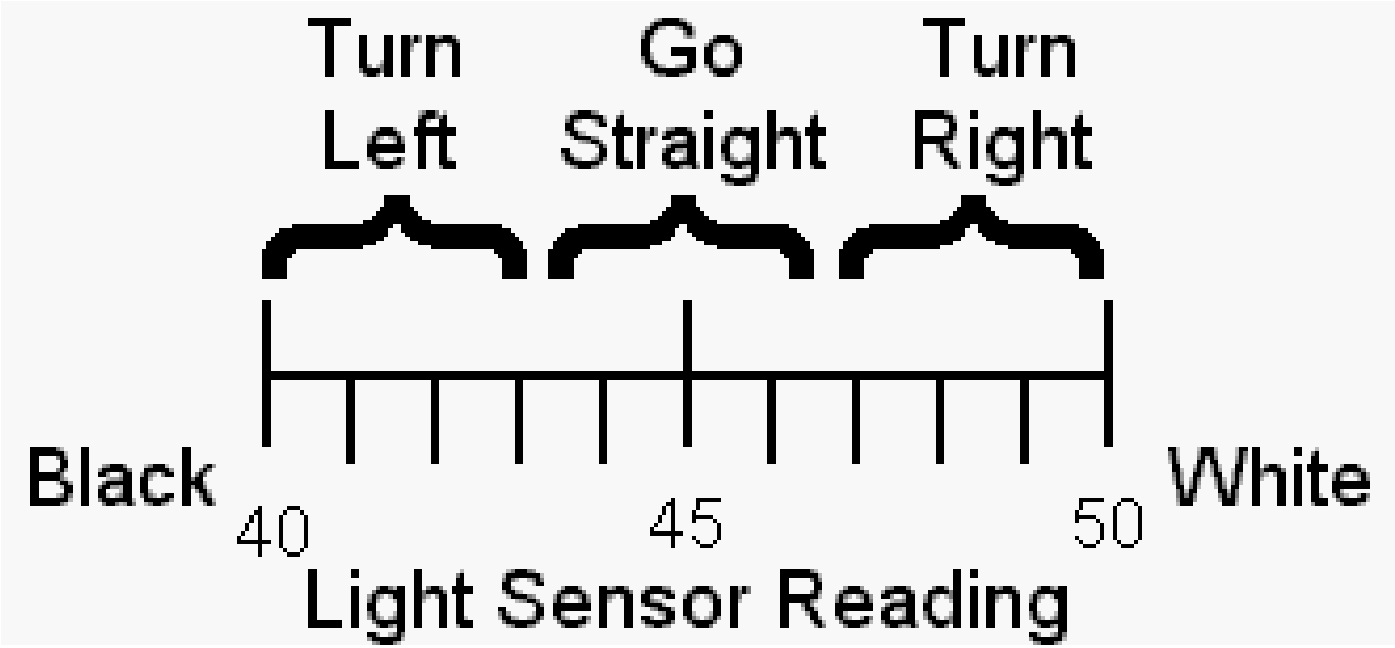
Stage 1 – Edge Following

- This program follows one side of the line



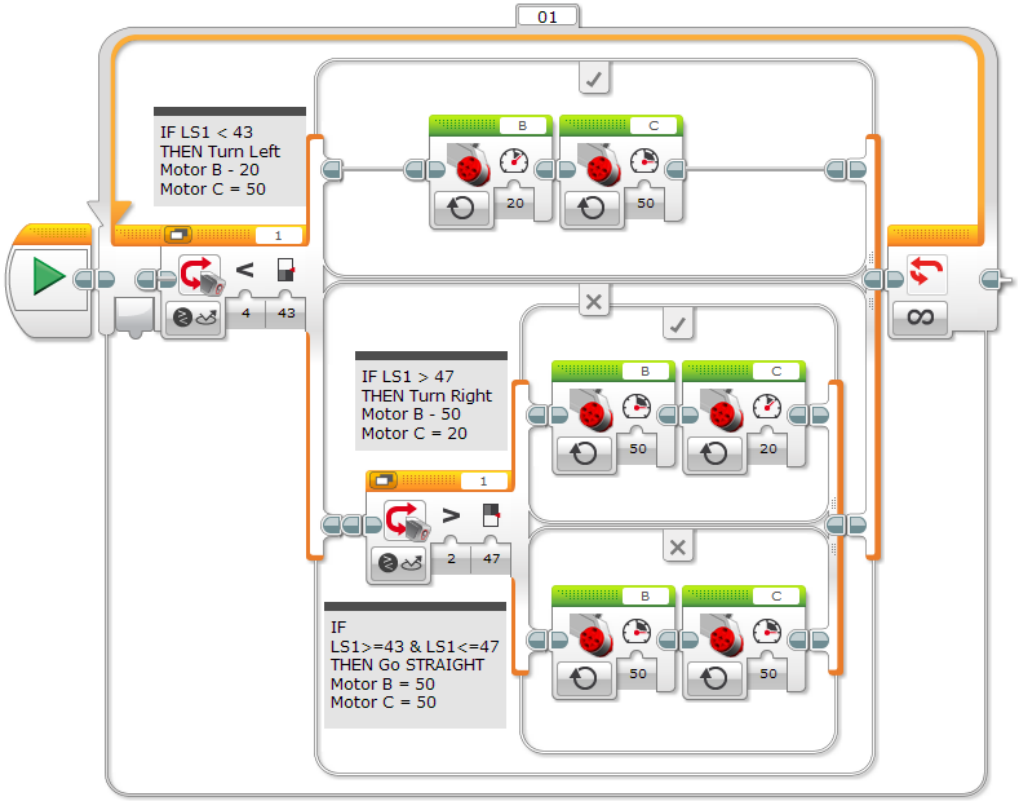
A Better Edge Follower

- Three Region Light Line
- We can now go straight



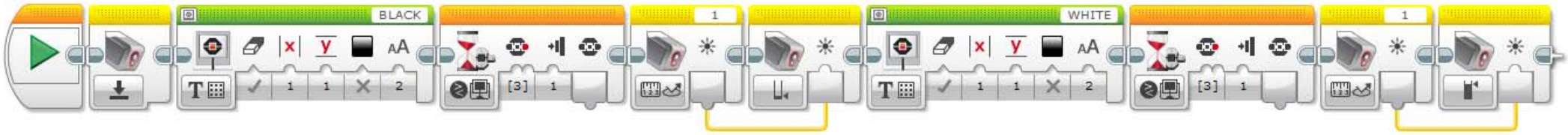
Stage 2 - A Better Edge Follower

- With a 3 level decision algorithm, we can now go straight.
- Even though this is still a single sensor Line Follower this logic allows the robot to move with less of a wriggle
- IF < 43 Turn Left
  IF > 47 Turn Right
  IF <=47 AND >=43 Straigh



Sensor Calibration

- Calibrating Light Sensors optimises their ability to give consistent readings
- Instead of percentage readings where white = 59 and black = 37 (approximately)
- Calibration sets the white value to 100 and black to 0.
- It also allows us to do some clever maths
- **Note**: Some Rescue robots constantly re-calibrate as they navigate the course adjusting the white and black levels!



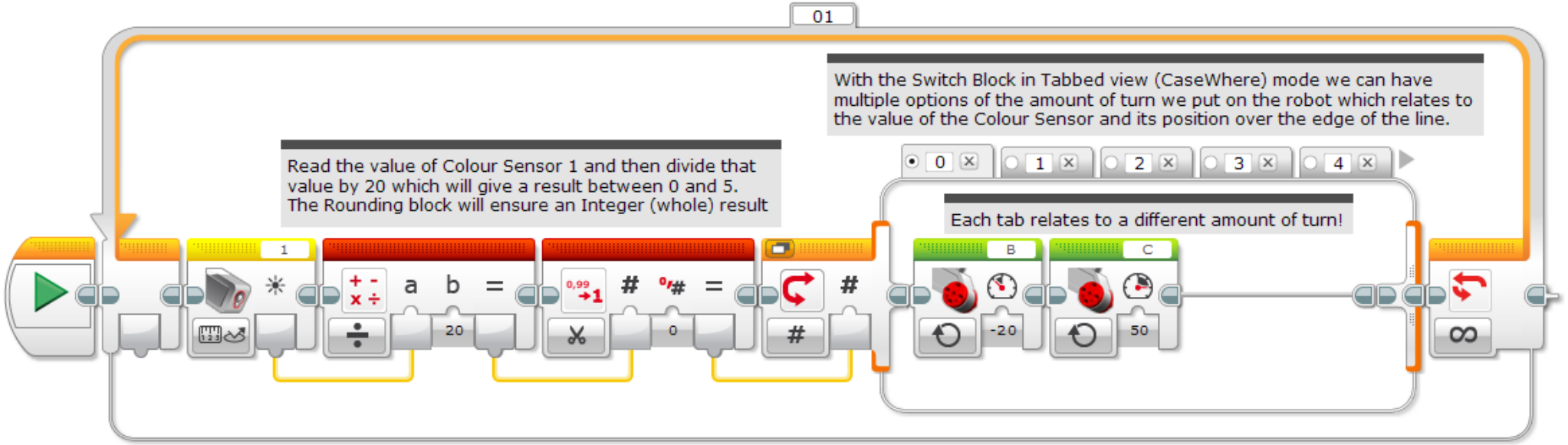
Smoothing out the Line Follow Action

Calibrated Light Sensor Reading	LS / 20 =	Integer Value
0	/20 =	0
5	/20 =	0
10	/20 =	0
15	/20 =	0
20	/20 =	1
25	/20 =	1
30	/20 =	1
35	/20 =	1
40	/20 =	2
45	/20 =	2
50	/20 =	2
55	/20 =	2
60	/20 =	3
65	/20 =	3
70	/20 =	3
75	/20 =	3
80	/20 =	4
85	/20 =	4
90	/20 =	4
95	/20 =	4
100	/20 =	5

- The table shows sensor values as it is moved over the edge of the line
- The full table would have 101 possible readings
- We will reduce 101 to 5 by dividing by 5
- Note: that we get more zeros than 5's. This can be adjusted by adding 1, 2 or 3 to the sensor reading before dividing by 5.
  You will need to experiment to get the best set of Integer Values. Use the Round Block.

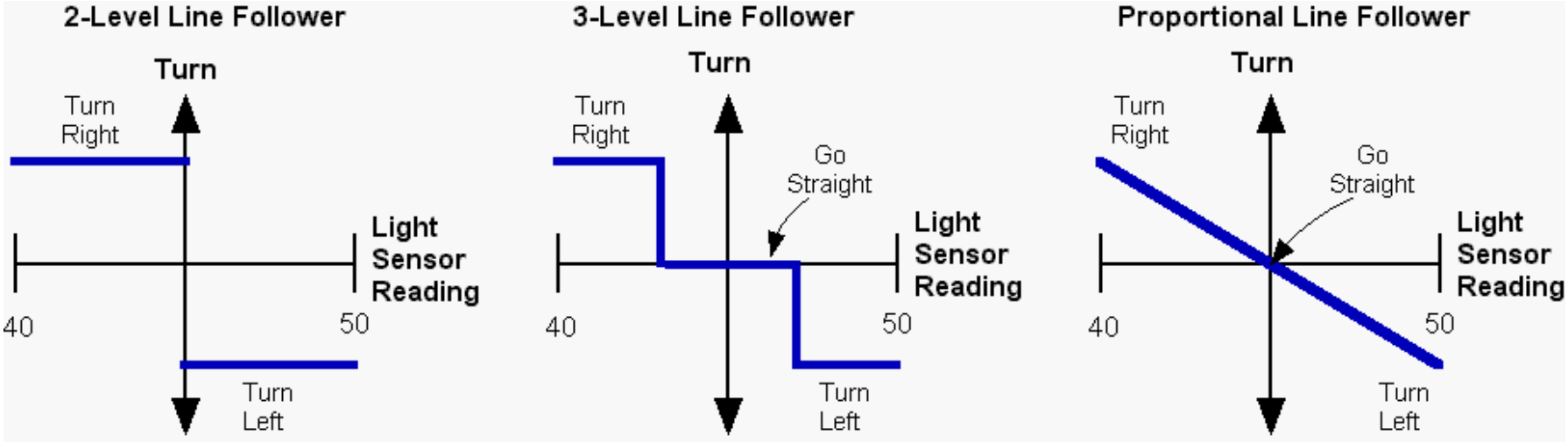
Multiple Options

- Now we can build in some smoothness using the Switch block, in Tabbed view (CaseWhere)
- Adjust the speed of the motors to get the robot following the line
- Try increasing the number of tabs to further smooth out the robot



Progression to Proportional (P)

- 2-level robot can only turn left or right well
- 3-level robot can also go straight
- Proportional robots have a linear relationship between the distance from the edge and the speed of the turn (motor speeds)



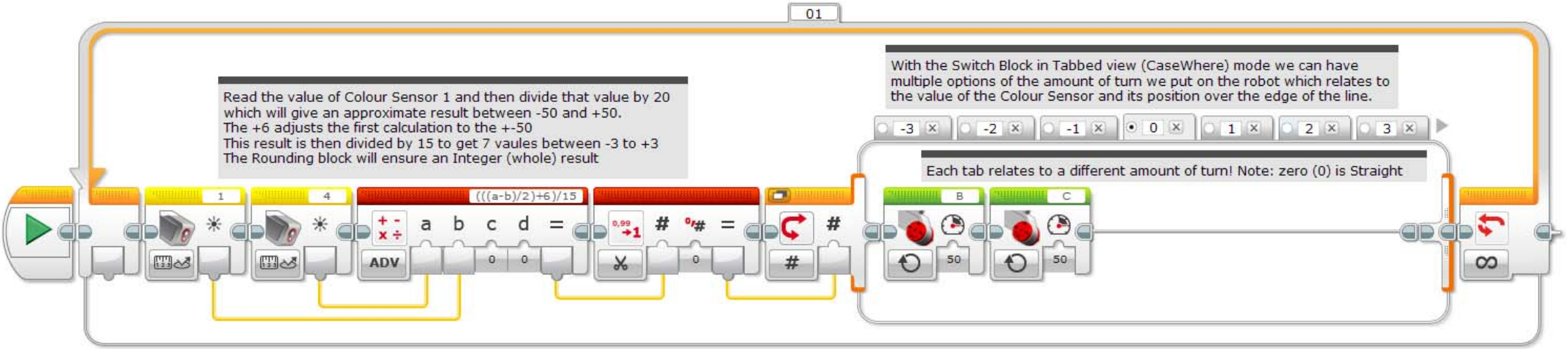
Two Sensors are better than One!

Light Sensor 1 Reading	Light Sensor 2 Reading	LS1 - LS2 / 2 =6	Int value /15
100	0	56	3
95	5	51	3
90	10	46	3
85	15	41	2
80	20	36	2
75	25	31	2
70	30	26	1
65	35	21	1
60	40	16	1
55	45	11	0
50	50	6	0
45	55	1	0
40	60	-4	-1
35	65	-9	-1
30	70	-14	-1
25	75	-19	-2
20	80	-24	-2
15	85	-29	-2
10	90	-34	-3
5	95	-39	-3
0	100	-44	-3

- Now the maths gets interesting
- By using 2 sensors we further smooth the robot
- (LS1 - LS2) / 2 gives us a range from -50 to +50
- Divide that by 15 to get our 7 options (3, 2, 1, 0, -1, -2, -3)
- However, we get to many -4's (out of range)
- Change- (LS1 – LS2) / 2 + 6 to fix the problem

Two Sensor Line Follower–The start of P!

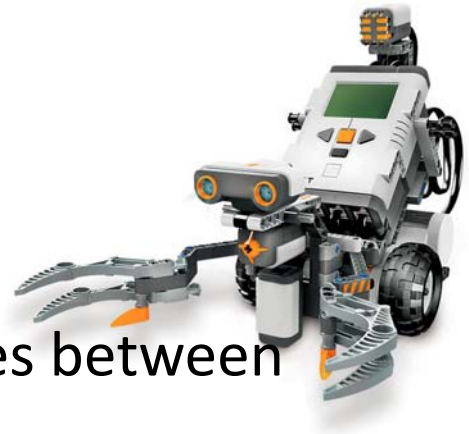
- Using the Advanced Maths block simplifies things in EV3
- (((a-b)/2)+6)/15
- The (a-b)/2 is the start of the Proportional solution



Proportional Line Following Multiple Sensors

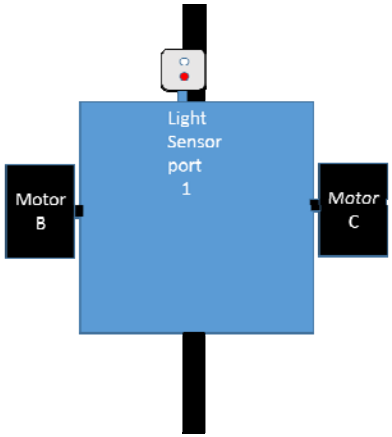
- To increase reliability and also allow the Rescue Robot to navigate the entire course more than one sensor is needed.
- The following examples take advantage of the Move Steering Block which does some of the maths for us in steering the robot.
- We will start again with a single Proportional Line Follower and progress all the way up to an 8 sensor array.
- **Note**: RoboCup Rescue does not allow pre-programmed PID Blocks OR Light Sensor arrays with built in PID algorithms.
  Teams must program the array using the individual light sensor values

EV3 Move Steering Block



- The Move Steering Block allows us to input steering values between +100 to –100
- A Steering Input of zero (0) will make the robot drive straight
- +/-50 will make the robot turn, with one motor on and the other stopped
- +/-100 will make the robot pivot, with one motor forward and the other motor in reverse
- If the pivot is to aggressive then adjust your program to a manageable max and min value of e.g. +/-75 for a less aggressive pivot

Single Sensor Proportional Follower

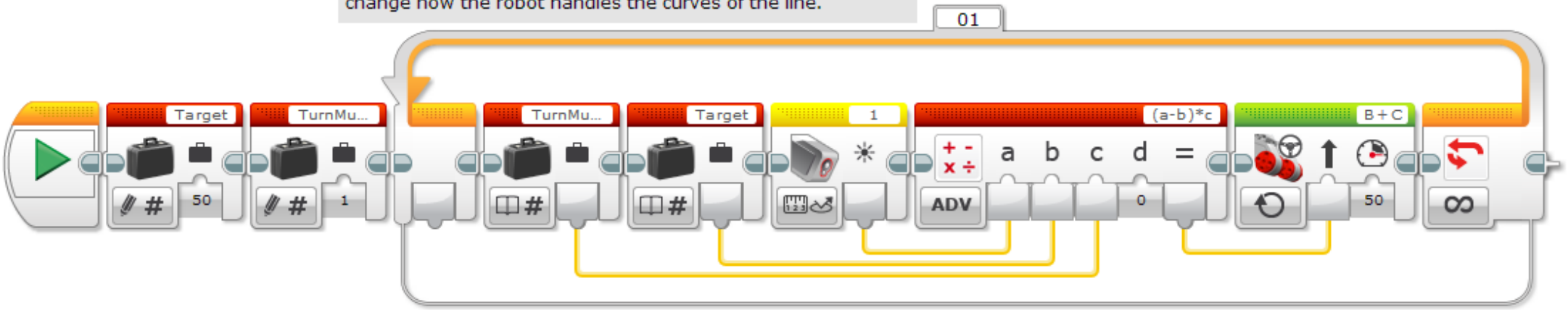


Single Sensor PID Line Following (Note: Proportional only)
Smoothing out the movement of an Edge Following Robot.

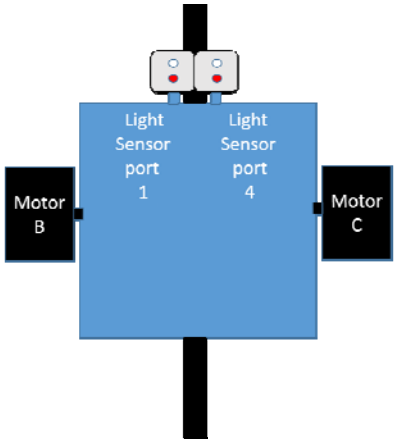
Target is the value of the Sensor when it is exactly over the Edge of the line. Should be the Threashold of Black and White.

TurnMultiplier is used to increase or decrease the reaction speed of the robot to it's relative position to the line.

Adjust the Motor Power and the TurnMultiplier up and down to change how the robot handles the curves of the line.



Two Sensor Proportional Follower

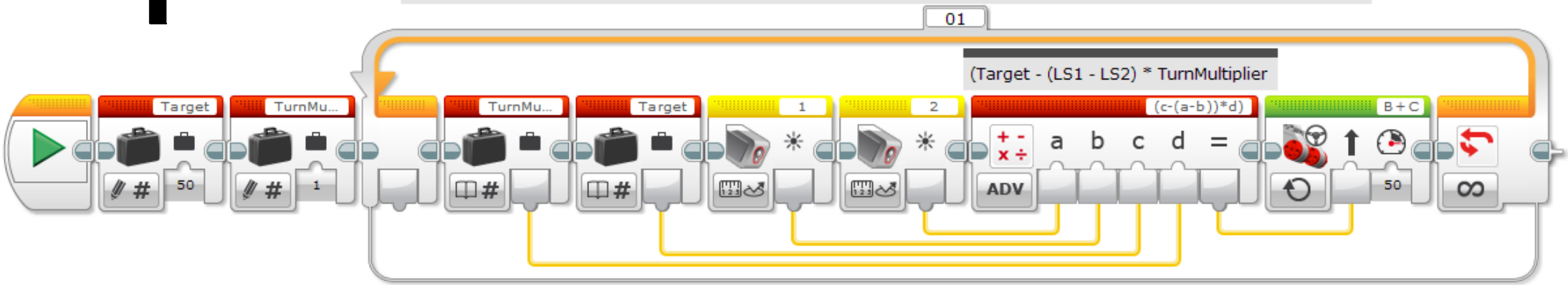


(2) Two Sensor PID Line Following (Note: Proportional only)
Smoothing out the movement of a Line Following Robot.

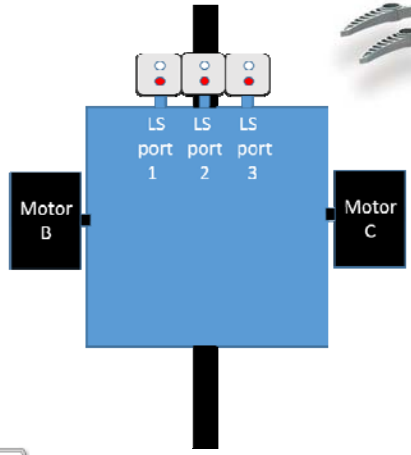
Target is the turn value of the Steer Block that will allow the robot to travel in a straight line. Zero (0) is straight.

TurnMultiplier is used to increase or decrease the reaction speed of the robot to it's relative position to the line.

Adjust the Motor Power and the TurnMultiplier up and down to change how the robot handles the curves of the line.



Three Sensor Proportional Follower

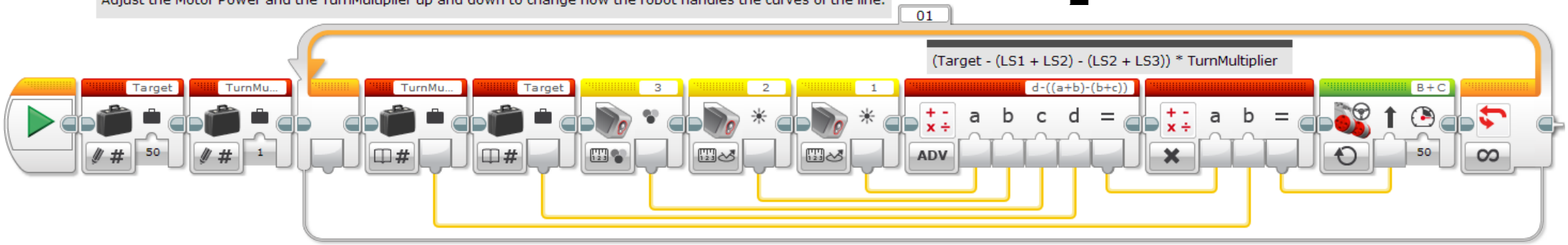


(3) Three Sensor PID Line Following (Note: Proportional only)
Smoothing out the movement of a Line Following Robot.

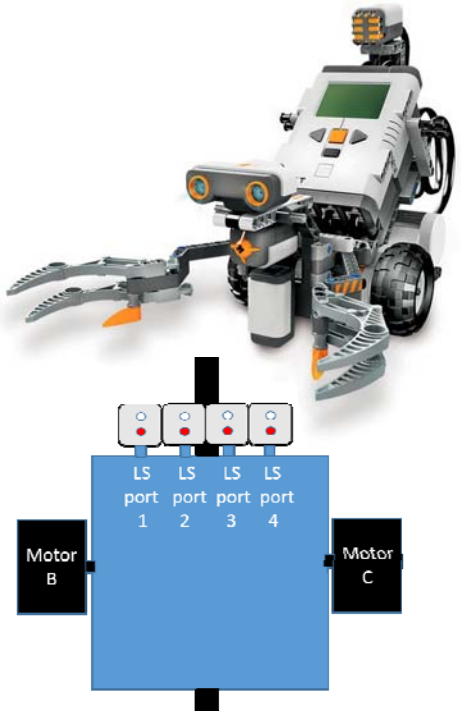
Target is the turn value of the Steer Block that will allow the robot to travel in a straight line. Zero (0) is straight.

TurnMultiplier is used to increase or decrease the reaction speed of the robot to it's relative position to the line.

Adjust the Motor Power and the TurnMultiplier up and down to change how the robot handles the curves of the line.



Four Sensor Proportional Follower

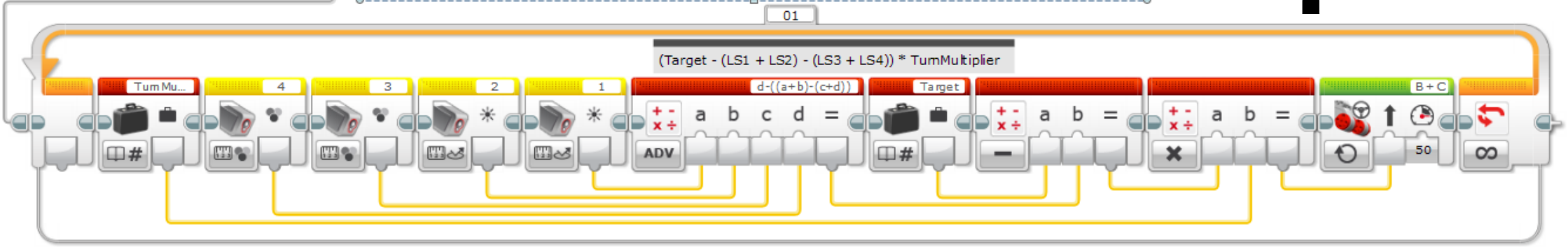


(4) Four Sensor PID Line Following (Note: Proportional only)
Smoothing out the movement of a Line Following Robot.

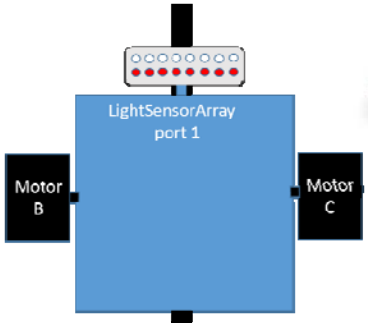
Target is the turn value of the Steer Block that will allow the robot to travel in a straight line. Zero (0) is straight.

TurnMultiplier is used to increase or decrease the reaction speed of the robot to it's relative position to the line.

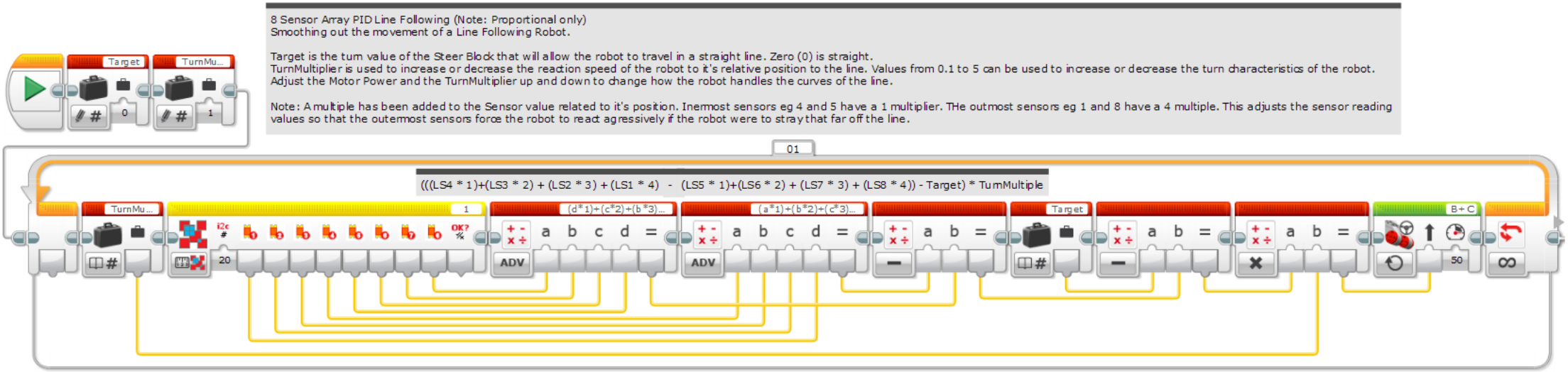
Adjust the Motor Power and the TurnMultiplier up and down to change how the robot handles the curves of the line.



Eight Sensor Proportional Follower



- This algorithm uses the Mindsensors LightSensorArray



- Note: The Mindsensors LineLeader is illegal to use in RoboCup Junior

Proportional Line Following in Rescue

- The Proportional Line Following algorithms may give a Rescue robot a line following advantage however;
- You will need to solve the problem of how the robot navigates the Intersections on the Rescue field.
- These examples will all need programming adjustments to suit robots
- The Multi-tasking method in part 2 of this tutorial can still be used to solve the Rescue challenge.

- Good luck and hope this helps you with development

Acknowledgements

- J. Sluka – http://www.inPharmix.com.au
- RoboCatz - http://robocatz.com/linefollowing.htm

3rd Party Sensors and Actuators

- MTA – Everything Lego Education
  http://www.teaching.com.au
- Omni Wheels – RotaCaster designed for Lego
  http://www.rotacaster.com.au/
- Linear Actuators – Firgelli have NXT and EV3 models
  http://www.firgelli.com
- HiTechnic – Official 3rd party Lego Sensors
  http://www.hitechnic.com/
- MindSensor – Unofficial 3rd party Lego Sensors
  http://www.mindsensors.com/
- Dexter Industries – Advanced sensors
  http://www.dexterindustries.com