# Donna

Saturday, June 20, 2015

Wheel size: 2.595 \* PI = 8.152 inches (212.08 mm). One odo = 8.152 / 1200 = 0.0068 inches (0.173mm).

Line width is about 0.725 inches or 106 odos.

Code: fc81b4e..3277a91

Put car to right of line

Enter key to start

>> FORWARD

[Odo:0] +++ FOLLOW\_LINE

\*[Odo:0] Position: 3155 L 23 23 23 761 140 23 3 23 R, YAW: 261.94

... ... PID. Position: 3.16, a\_speed: 64, b\_speed: 64

>> FORWARD

\*[Odo:2] Position: 3155 L 23 23 23 761 140 23 3 23 R, YAW: 261.94

[Odo:2] +++ FOLLOW\_LINE

... ... PID. Position: 3.16, a\_speed: 64, b\_speed: 64

>> FORWARD

\*[Odo:10] Position: 3155 L 23 23 23 761 140 23 3 23 R, YAW: 261.94

[Odo:10] +++ FOLLOW\_LINE

... ... PID. Position: 3.16, a\_speed: 64, b\_speed: 64

>> FORWARD

\*[Odo:23] Position: 3155 L 23 23 23 761 140 23 3 23 R, YAW: 261.94

[Odo:24] +++ FOLLOW\_LINE

... ... PID. Position: 3.16, a\_speed: 64, b\_speed: 64

>> FORWARD

So loop is reading about every 12 odometries, or 0.08 inches (2 mm). Then:

\*[Odo:1888] Position: 2804 L 1000 861 658 436 300 258 350 658 R, YAW: 265.37

[Odo:1892] +++ FOLLOW\_LINE

... ... FOUND start of crossing, left: 1, right: 1

\*[Odo:1932] Position: 2804 L 1000 861 658 436 300 258 350 658 R, YAW: 265.37

[Odo:1935] +++ FOLLOW\_LINE\_END

\*[Odo:1963] Position: 2804 L 1000 861 658 436 300 258 350 658 R, YAW: 265.37

[Odo:1967] +++ FOLLOW\_LINE\_END

\*[Odo:1998] Position: 2804 L 1000 861 658 436 300 258 350 658 R, YAW: 265.37

[Odo:2002] +++ FOLLOW\_LINE\_END

\*[Odo:2031] Position: 2804 L 1000 861 658 436 300 258 350 658 R, YAW: 265.37

[Odo:2035] +++ FOLLOW\_LINE\_END

\*[Odo:2066] Position: 2804 L 1000 861 658 436 300 258 350 658 R, YAW: 265.37

[Odo:2072] +++ FOLLOW\_LINE\_END

\*[Odo:2098] Position: 2804 L 1000 861 658 436 300 258 350 658 R, YAW: 265.37

[Odo:2102] +++ FOLLOW\_LINE\_END

\*[Odo:2132] Position: 2804 L 1000 861 658 436 300 258 350 658 R, YAW: 265.37

[Odo:2136] +++ FOUND\_END

\*[Odo:2161] Position: 2804 L 1000 861 658 436 300 258 350 658 R, YAW: 265.37

[Odo:2165] +++ FOUND\_END

\*[Odo:2188] Position: 0 L 0 0 0 8 0 0 0 0 R, YAW: 265.87

[Odo:2189] +++ FOUND\_END

\*[Odo:2204] Position: 0 L 0 0 0 8 0 0 0 0 R, YAW: 265.87

[Odo:2205] +++ FOUND\_END

\*[Odo:2218] Position: 0 L 0 0 0 8 0 0 0 0 R, YAW: 265.87

[Odo:2220] +++ FOUND\_END

\*[Odo:2231] Position: 0 L 0 0 0 8 0 0 0 0 R, YAW: 265.87

[Odo:2232] +++ FOUND\_END

\*[Odo:2239] Position: 0 L 0 0 0 8 0 0 0 0 R, YAW: 265.87

[Odo:2239] +++ FOUND\_END

\*[Odo:2245] Position: 0 L 0 0 0 8 0 0 0 0 R, YAW: 265.87

[Odo:2245] +++ FOUND\_END

\*[Odo:2249] Position: 0 L 0 0 0 8 0 0 0 0 R, YAW: 265.87

[Odo:2250] +++ FOUND\_END

\*[Odo:2252] Position: 0 L 0 0 0 8 0 0 0 0 R, YAW: 265.87

[Odo:2252] +++ FOUND\_END

\*[Odo:2253] Position: 0 L 0 0 0 8 0 0 0 0 R, YAW: 265.87

[Odo:2253] +++ FOUND\_END

Car stopped approximately 0.72 inches beyond end-symbol end (18mm) [105 odos], is further to left. End-symbol is about 2.12 inches (54mm) [318 odos].

At 1892 odos, found line start. At 2136 odos, found line end. Sensor determined line width was 244 odos instead of 318.



6/20/2015 12:09 RUN 2 code: 3277a91..be21ba5

Start with motor to right of line over sensors 2 and 3 (1 is leftmost).

Car corrected so line is between 3 and 4

Enter key to start

>> FORWARD

\*[Odo:0] Position: 1744 L 25 253 738 48 3 25 3 25 R, A: 64, B: 64, YAW: 271.90

[Odo:0] +++ FOLLOW\_LINE

\*[Odo:1] Position: 1744 L 25 253 738 48 3 25 3 25 R, A: 64, B: 64, YAW: 271.90

[Odo:1] +++ FOLLOW\_LINE

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\*[Odo:1279] Position: 1737 L 0 260 731 0 0 286 145 218 R, A: 64, B: 64, YAW: 273.07

[Odo:1287] +++ FOLLOW\_LINE

... ... FOUND start of crossing, left: 1, right: 1

\*[Odo:1320] Position: 2869 L 218 663 663 570 356 286 145 218 R, A: 64, B: 64, YAW: 273.07

[Odo:1327] +++ FOLLOW\_LINE\_END

\*[Odo:1357] Position: 2869 L 218 663 663 570 356 286 145 218 R, A: 64, B: 64, YAW: 273.07

[Odo:1364] +++ FOLLOW\_LINE\_END

\*[Odo:1393] Position: 2869 L 218 663 663 570 356 286 145 218 R, A: 64, B: 64, YAW: 273.07

[Odo:1399] +++ FOLLOW\_LINE\_END

\*[Odo:1428] Position: 2869 L 218 663 663 570 356 286 145 218 R, A: 64, B: 64, YAW: 273.07

[Odo:1435] +++ FOLLOW\_LINE\_END

\*[Odo:1460] Position: 2869 L 218 663 663 570 356 286 145 218 R, A: 64, B: 64, YAW: 273.07

[Odo:1468] +++ FOLLOW\_LINE\_END

\*[Odo:1496] Position: 2869 L 218 663 663 570 356 286 145 218 R, A: 64, B: 64, YAW: 273.07

[Odo:1504] +++ FOLLOW\_LINE\_END

\*[Odo:1531] Position: 2869 L 218 663 663 570 356 286 145 218 R, A: 0, B: 0, YAW: 273.07

[Odo:1536] +++ FOUND\_END

\*[Odo:1560] Position: 2869 L 218 663 663 570 356 286 145 218 R, A: 0, B: 0, YAW: 273.07

[Odo:1566] +++ FOUND\_END

\*[Odo:1586] Position: 2374 L 30 30 540 323 0 6 0 6 R, A: 0, B: 0, YAW: 272.21

[Odo:1588] +++ FOUND\_END

Starting sensor array: 25 253 738 48 3 25 3 25

Sensor array at line start: 0 260 731 0 0 286 145 218

THERE WAS NO PID CORRECTION. The next sensor reading is:

218 663 663 570 356 286 145 218

which is quite a bit of variation for the line. By near line end, the sensors are (identically)

218 663 663 570 356 286 145 218

After line end, with line continuation, sensors are:

30 30 540 323 0 6 0 6

The line is correctly between sensors 3 and 4.

Crossing line is 0.73in (109 odos). Found start at 1892, found end at 2136 or 244 odos (1.63in).

From line end at 2136 to stop at 2253, took 117 odos to stop (0.78in).

CONCLUSIONS:

* Need to stop faster.
* Sensors have widely different values for a black line. The arbitrary 218 value is probably 200 high. **CHANGING THRESHOLD TO 120**.



2015 06 20 12:41 RUN 3 Code: be21ba5..0fbb27e

Adding faster PID (+/- 20 instead of 10), fast stop mode.

Start between sensors 4 and 5, 20degree angle of backend to the left (yaw right).

Enter key to start

>> FORWARD

\*[Odo:0] Position: 3475 L 3 3 3 483 438 28 3 28 R, A: 64, B: 64, YAW: 269.84

[Odo:0] +++ FOLLOW\_LINE

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\*[Odo:955] Position: 1102 L 51 965 173 0 6 6 6 6 R, A: 64, B: 64, YAW: 278.51

[Odo:960] +++ FOLLOW\_LINE

\*[Odo:992] Position: 90 L 583 58 0 0 0 0 0 0 R, A: 64, B: 64, YAW: 278.34

[Odo:995] +++ FOLLOW\_LINE

... ... FOUND start of crossing, left: 1, right: 0

\*[Odo:1033] Position: 90 L 583 58 0 0 0 0 0 0 R, A: 64, B: 64, YAW: 278.34

[Odo:1036] +++ FOLLOW\_LINE\_END

\*[Odo:1066] Position: 90 L 583 58 0 0 0 0 0 0 R, A: 64, B: 64, YAW: 278.34

[Odo:1070] +++ FOLLOW\_LINE\_END

\*[Odo:1096] Position: 90 L 583 58 0 0 0 0 0 0 R, A: 64, B: 64, YAW: 278.34

[Odo:1100] +++ FOLLOW\_LINE\_END

\*[Odo:1129] Position: 90 L 583 58 0 0 0 0 0 0 R, A: 64, B: 64, YAW: 278.34

[Odo:1133] +++ FOLLOW\_LINE\_END

\*[Odo:1165] Position: 90 L 583 58 0 0 0 0 0 0 R, A: 64, B: 64, YAW: 278.34

[Odo:1168] +++ FOLLOW\_LINE\_END

\*[Odo:1198] Position: 90 L 583 58 0 0 0 0 0 0 R, A: 64, B: 64, YAW: 278.34

[Odo:1202] +++ FOLLOW\_LINE\_END

\*[Odo:1232] Position: 90 L 583 58 0 0 0 0 0 0 R, A: 0, B: 0, YAW: 278.34

[Odo:1235] +++ FOUND\_END

\*[Odo:1260] Position: 90 L 583 58 0 0 0 0 0 0 R, A: 0, B: 0, YAW: 278.34

[Odo:1263] +++ FOUND\_END

\*[Odo:1283] Position: 5356 L 220 0 0 85 403 718 835 1000 R, A: 0, B: 0, YAW: 278.92

[Odo:1287] +++ FOUND\_END

\*[Odo:1304] Position: 5356 L 220 0 0 85 403 718 835 1000 R, A: 0, B: 0, YAW: 278.92

[Odo:1306] +++ FOUND\_END

\*[Odo:1321] Position: 5356 L 220 0 0 85 403 718 835 1000 R, A: 0, B: 0, YAW: 278.92

[Odo:1323] +++ FOUND\_END

\*[Odo:1333] Position: 5356 L 220 0 0 85 403 718 835 1000 R, A: 0, B: 0, YAW: 278.92

[Odo:1336] +++ FOUND\_END

\*[Odo:1343] Position: 5356 L 220 0 0 85 403 718 835 1000 R, A: 0, B: 0, YAW: 278.92

[Odo:1344] +++ FOUND\_END

\*[Odo:1349] Position: 5356 L 220 0 0 85 403 718 835 1000 R, A: 0, B: 0, YAW: 278.92

[Odo:1350] +++ FOUND\_END

\*[Odo:1353] Position: 5356 L 220 0 0 85 403 718 835 1000 R, A: 0, B: 0, YAW: 278.92

[Odo:1353] +++ FOUND\_END

Starting sensors: 3 3 3 483 438 28 3 28

Sensors at line start: 51 965 173 0 6 6 6 6

ROBOT IS PAST LEFT SENSOR, STILL AT 20 DEGREE ANGLE.

NOTE PID HAS NOT HAPPENED

Sensors at line end: 583 58 0 0 0 0 0 0

Stopped because odometry went more than 200.

From motor stop to full stop: 1353-1235 = 118 or 0.79 inches.



2015 06 20 13:23 RUN4 Code: 0fbb27e..747ba2a, 747ba2a..b97c859, b97c859..3225650

Adding call to motor.Forward at end of FOLLOW\_LINE strategy. Static variables. Stop loggin when at STOP.

Change FIND\_LINE\_END strategy to timeout after odo exceeds 700 instead of 200.

Motor between sensors 2 and 3, yaw right 20 degrees.

Car veered way left then right.



2015 06 20 13:53 RUN 4 Code: 3225650..261e8cd

return pid to +/- 10 variation. Fix bad position of call to Motor::Forward

veered way too left. Stopped after loosing line.

Odoend – start = 325 = 2.178 In

It can take about 0.1 sec to travers the .725 inch line (106 odos), which at 2500 usec max sample time for IR, gives max 41 samples per line traversal.



## Sunday, June 21, 2015, 21:15

This may be boring to you, but I finally got my first experiment to work, and I thought I’d share what I learned from the log data spewed out while the robot ran. This gives me a lot of data about the limits of my robot, velocities, common performance and things to look out for.

4961.75 :: --- FOLLOW\_LINE correcting with left turn [Odo:931] State: FOLLOW\_LINE, Position: 2.87   L 0 0 105 673 0 0 0 0 R  , YAW: 270.00, s: 0, e: 0, len: 0

4982.02 :: --- FOLLOW\_LINE on course [Odo:939] State: FOLLOW\_LINE, Position: 3.28   L 168 168 168 1000 394 168 89 168 R  , YAW: 272.24, s: 0, e: 0, len: 0

5008.57 :: --- FOLLOW\_LINE on course [Odo:951] State: FOLLOW\_LINE, Position: 3.24   L 178 178 178 1000 405 100 100 178 R  , YAW: 267.76, s: 0, e: 0, len: 0

5035.23 :: --- FOLLOW\_LINE on course [Odo:965] State: FOLLOW\_LINE, Position: 3.26   L 168 84 168 1000 263 84 84 168 R  , YAW: 269.55, s: 0, e: 0, len: 0

5061.39 :: --- FOLLOW\_LINE on course [Odo:980] State: FOLLOW\_LINE, Position: 3.09   L 168 168 310 1000 236 89 89 168 R  , YAW: 269.11, s: 0, e: 0, len: 0

5087.70 :: +++ FOLLOW\_LINE FOUND LINE START [Odo:1005] State: FIND\_LINE\_END, Position: 2.74  \*L 373 373 373 1000 152 152 152 152 R  , YAW: 267.32, s: 1001, e: 1001, len: 0

5239.12 :: +++ FIND\_LINE\_END FOUND LINE END BY IR [Odo:1135] State: FOUND\_END, Position: 2.50   L 168 0 168 1000 26 0 0 26 R  , YAW: 269.53, s: 1001, e: 1134, len: 133

5260.81 :: +++ FOUND\_END [Odo:1159] State: FOUND\_END, Position: 2.90   L 0 0 110 1000 42 0 0 0 R  , YAW: 268.67, s: 1001, e: 1134, len: 133

==== ==== STATS

loopCount: 80, avg loop duration: 17644.75

usec at start: 3869600, at end: 5281180, duration: 1411580

lineSensor sumLineSensorRead: 159756, avg read duration: 1996.95

sensorStick sumSensorStickRead: 132456,  avg read dration: 1655.70

5324.50 :: Final dump [Odo:1229] State: STOP, Position: 2.90   L 0 0 110 1000 42 0 0 0 R  , YAW: 268.67, s: 1001, e: 1134, len: 133

5370.69 :: +++ STOP [Odo:1259] State: STOP, Position: 2.85   L 0 31 173 1000 31 0 0 0 R  , YAW: 269.05, s: 1001, e: 1134, len: 133

5406.10 :: +++ STOP [Odo:1275] State: STOP, Position: 2.85   L 0 31 173 1000 31 0 0 0 R  , YAW: 269.33, s: 1001, e: 1134, len: 133

5441.49 :: +++ STOP [Odo:1288] State: STOP, Position: 2.70   L 0 100 184 1000 31 0 0 0 R  , YAW: 268.89, s: 1001, e: 1134, len: 133

5477.07 :: +++ STOP [Odo:1295] State: STOP, Position: 2.71   L 31 100 173 1000 31 0 0 0 R  , YAW: 269.55, s: 1001, e: 1134, len: 133

5512.70 :: +++ STOP [Odo:1297] State: STOP, Position: 2.67   L 31 100 242 1000 31 0 0 0 R  , YAW: 270.00, s: 1001, e: 1134, len: 133

This is near the end of my experiment, which was to follow a line until an intersection was found (start of line) and then continue on until the other side of the intersecting line was found and then stop..

The first column is my millisecond counter (i.e., the myMicros() / 1000 value, minus the base time when the program started). Followed by the old strategy state name, then the new strategy state, then the current line position (3.5 is centered on the line, < 3.5 is left of center — yaw left, > 3.5 is right of center — yaw right), then “L” followed by the 8 IR sensor values then “R”. If the lefmost or rightmost sensors detect a line, the “L” becomes “**\***L” or the “R” becomes “R**\***” (i.e. an asterisk is added). Followed by heading (yaw) in degrees, then the odometer reading when the near edge of a line is detected (s) and the odometer when far edge of a line is detected (e) and the length (width) in “odos” of the detected line.

So, near the end of my experiment you see:

At 4961.75 milliseconds, having traveled 931 odos, the robot is trying to follow the line but the line position has drifted down to 2.87, much less than 3.5 so the robot is trying to do a left turn to move it more over the center of the line. The current heading is 270 degrees and no line has been detected yet.

At 4982.02 milliseconds, having traveled 939 odos and having done a small left turn, we’re back within an acceptable line position (I don’t correct until the line position is less than 3 or greater than 4). Notice that only 19 milliseconds has elapsed between strategy decisions and the robot has travelled only 8 odos (about 0.054 inches).

Skipping until 5087.7 milliseconds, we see the robot has still been drifting left a bit (line position is now 2.74 and the yaw is down to 267.32 degrees) but it found the beginning edge of the line at 1005 odos. Normally, I would do a yaw correction but I don’t while I’m in the middle of detecting the end of a line. Given that I just manually placed the robot near a line on a piece of paper to start, this is close to the expected 1029 odos for the beginning of the line. The robot is tilted left a bit so you see the left set of sensor values are at 373 and the center line is still at 1000 while the right ones are still essentially white (152). Note the log says “**\***L” meaning it thinks a left turn has been detect while the right sensor says “R” without the asterisk as it hasn’t see the line yet. The robot strategy now changes to FIND\_LINE\_END.

At 5239.12 milliseconds, the robot has found the end of the line at odo 1135. You see at the end of the log line that the line start was at 1001 odos and the end is  1134 and the length is 133 odos. The expectation was 106 odos (0.725 inches), so it’s pretty close. The robot state changes to FOUND\_END which is where I would normally make a decision about what to do. For now, the decision is to just stop.

At 5260.81 milliseconds I try to stop to robot. I’m at 1159 odos. The outer loop will now keep pinging the sensors until the odometer quits changing so I can see how far the robot goes when told to stop.

The line beginning with “==== ==== STATS” is the final stats. We see that the strategy loop was executed 80 times, each loop taking about 17.6 milliseconds (the log is showing usecs instead of ms for the duration). Each strategy loop happens after the robot travels about 0.05 inches (from above). It took 1.41 seconds to travel the 7 inches and then to stop beyond the line. I can even compute the velocity of the robot. I went 1229 odos (8.3572 inches) in 1.411 sec or 5.9 inches per second. Divide by the wheel circumference of 8.152 inches we get 0.73 RPM.

Let’s compare that to the speed while in the middle of the loop where a yaw correction is taking place. At 4961 ms we are at odo 931. At 5239 we are at odo 1135. We’ve traveled 204 odos (1.387 in) in 278 ms or 5 inches/second or 0.61 RPM. So doing the yaw correction slowed things down, which is expected because the way I do yaw correction is to stop the robot, do very short right or left turns until the line is nearly centered again, and then go forward again.

Looking further at the stats, I see it took on average 1.996 ms to read the IR sensors, and 1.655 ms to read the heading sensor via I2C.

The dump continues until the odometer doesn’t change. We tried to stop at 1159 odos but didn’t come to a complete halt until 1297 odos, traveling 138 odos or 0.938 inches. Not exactly stopping on a dime. But that’s not a big bad thing. My sensors are out in front of the robot, and my intent is to do a right or left turn in place to find the line before continuing. It would work best if the line moved more towards the center of the robot when I execute my turn. I may even want to wait stopping until I’m more likely to be nearly centered on the line.

TODO

Even though I only found the left part of the crossing line to start, I need to keep track of if the right part is found while looking for the other side of the line.

I need to change my FOUND\_END strategy to then decide on the left-most possible turn (i.e. a left turn, continue or a right turn) and execute that turn — this will be a simple left-hand maze solver strategy.

I need to detect the end of the maze. Actually, that part is build in there as the end-of-line finder will stop when either it finds the other side of the line or it has traveled a known maximum distance.

I need to detect dead ends and execute a 180 degree turn.

Actually I plan on using my heading sensor to execute 90 and 180 degree turns — the plan is to turn maybe 80 or 170 degrees regardless of the line sensor and then use the line sensor to complete the turn.