Lab Report, Introductory Course in engineering methodology
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Programming the Arduino Rollbot

to pilot it through a course

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1 Introduction

The purpose of the project is to construct an algorithm which can navigate the rollbot through a course by following the black line. (1)" Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards can read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can program your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino program (based on C Language), and the Arduino Software (IDE)." In this project we are going to use the sensors to detect the black line on the track. The rollbot is going to start on a black line perpendicular to the main line which the rollbot is going to follow through. The rollbot should follow the line and make any kind of turns for a number of laps clockwise and counter clockwise.

2 Method

2.1 Flowchart

This a flowchart of the code. At the beginning five were initialized sensors, laps number(unknown), opposite direction laps(unknown), total laps (laps number plus opposite direction laps) and the counter to 0. There is a loop that reads the inputs from the five sensors. If all sensors are black, add one to the counter, and then if the counter equals laps number " follow junction" which is when the rollbot have done the number of laps required clockwise. if it does not equal to laps number we have another if statement here if counter does not equal to total laps number continue straight and if it does equal then stop. Then if sensor1 and sensor5 are white and sensor2 or sensor3 or sensor4 is black go straight but if it is false add another if statement if sensor1 and sensor2 are black and sensor5 is white turn left, if it is false add another if statement if sensor5 and sensor4 are black and sensor1 is white turn right.

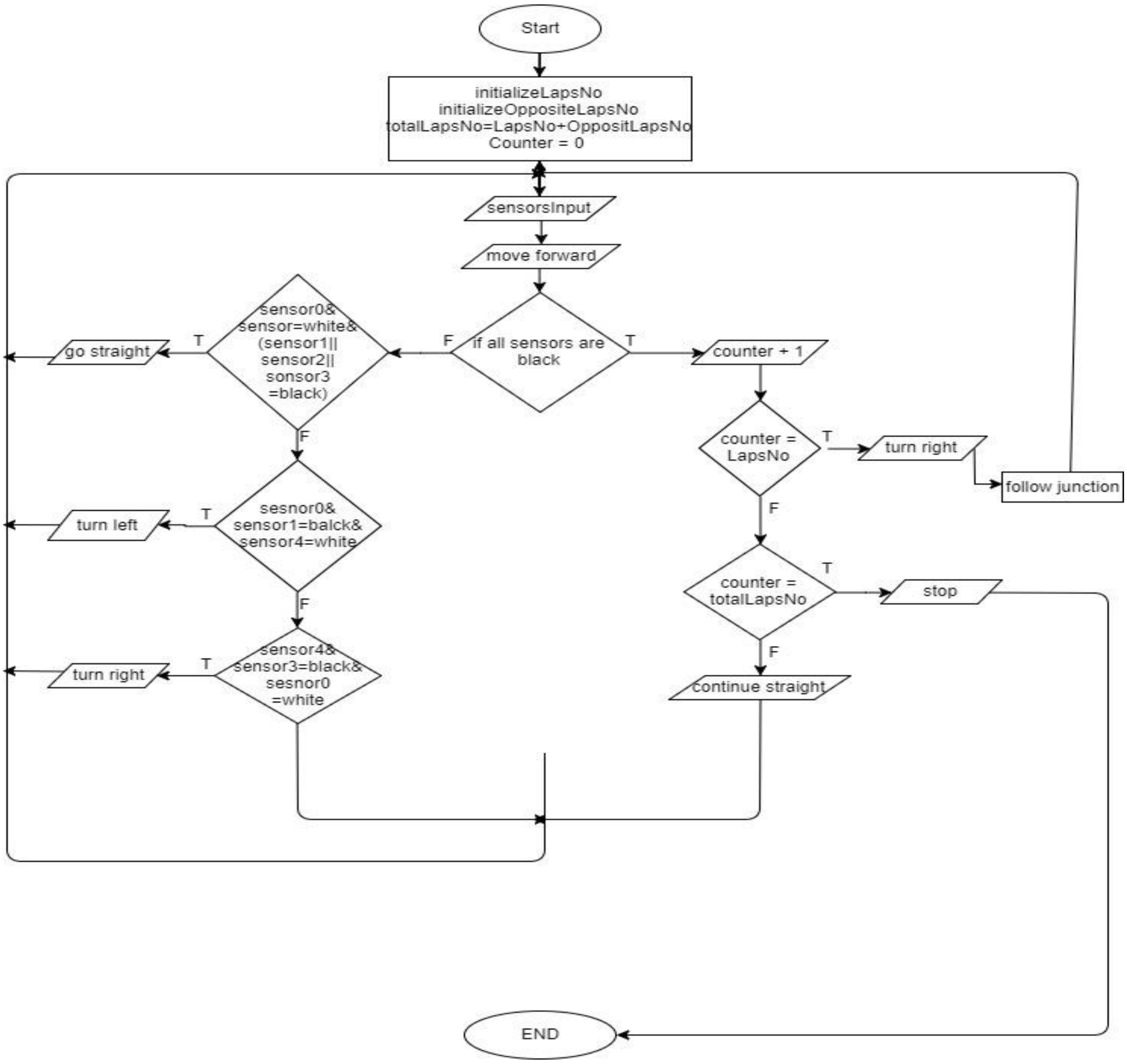

Fig 2. Flowchart

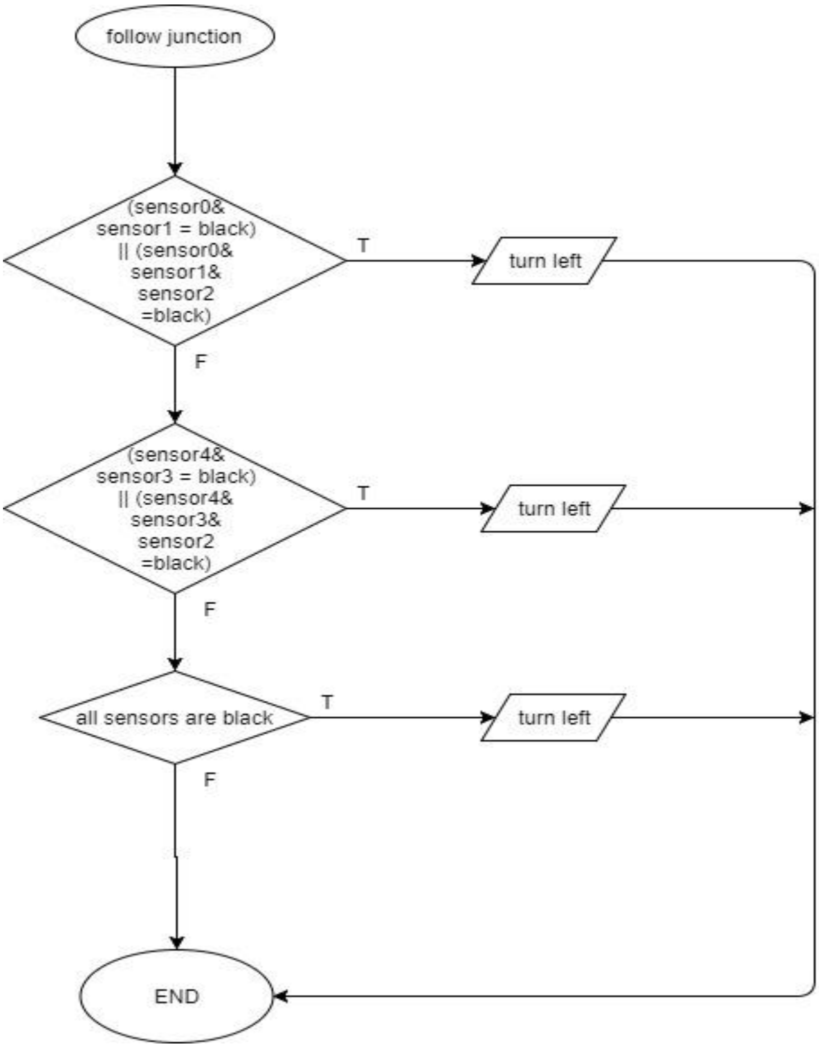

Figure 3. Follow junction chart.

2.2 Sensor study

There are five sensors and each sensor consist of an infrared LED and a receiver. The LED sends an infrared light for the detector to detect the light that is reflecting from a surface. Both the IR LED and the detector are fixed on an angle, so it would be possible to send and receive the light. When sensors are placed above a black surface, the IR light barely reflects therefore we get a very small value from the detector, and when placed on a white surface the infrared light reflects at its highest which gives us a higher output value. 2)“The detector in the Sharp IR sensor is like the imaging sensor found in digital cameras. Since the detector and the IR LED have a fixed distance and orientation relative to each other, the distance of an object will affect the angle at which the light from the IR LED hits the receiver. By looking at where the light hits the detector, it is possible to calculate the angle of the light and from that angle derive the distance to the object (all of which is done by the sensor itself)”.

Figure 4. Infrared(IR) LED and Detector positions

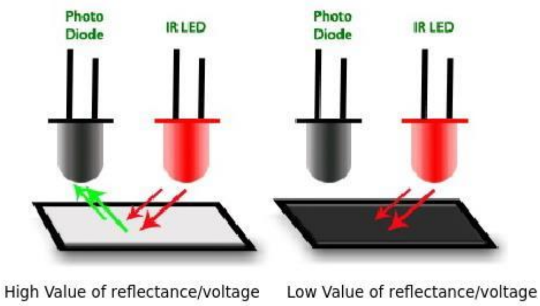

Figure 5. Infrared(IR) reflection

Figure 5 illustrates our method in testing the sensors by moving the sensors from the middle of the line horizontally. We shifted each sensor horizontally across the black line. We tested all the sensors with the same technique that we measured to get a black reading (position 1), black reading affected by white (position 2), half black & half white reading (position 3), white affected by black reading (position 4) and white reading (position 5).

Figure 6. Illustration of sensor reading measuring

3 Result

3.1 Sensor Testing Results

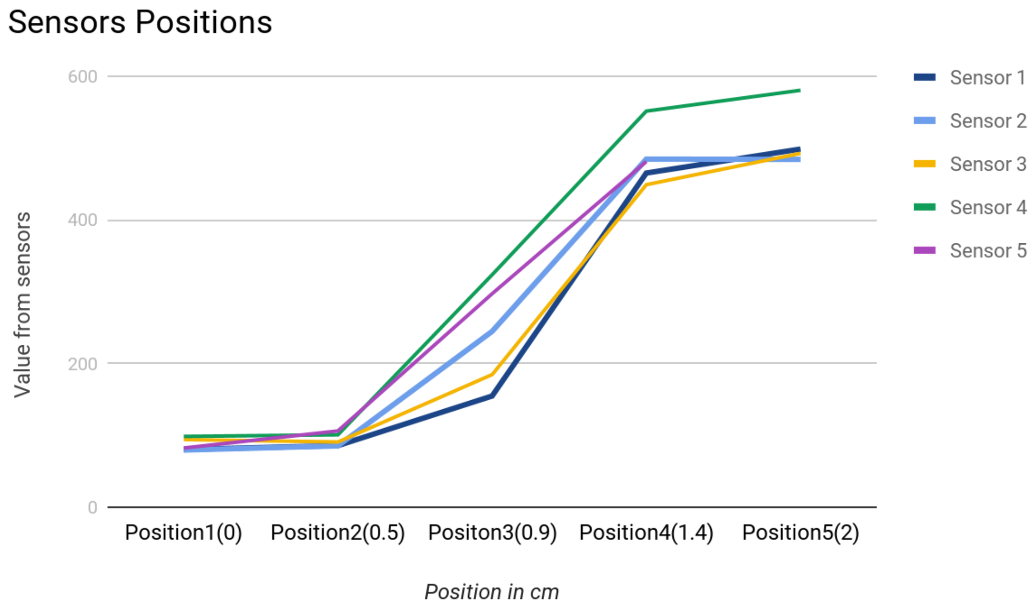

Figure 7. Sensor Output Average

Table 1. Sensor 1 test results

	test 1	test 2	test 3	test 4	test 5	Average
Position 1	80	80	81	81	80	80.4
Position 2	87	87	84	86	85	85.8
Position 3	154	155	154	156	155	154.8
Position 4	466	465	464	466	465	465.2
Position 5	498	498	499	498	500	498.6

The rest of the results of sensor 2,3,4 and 5 you can find it on appendix A

3.2 Speed testing results

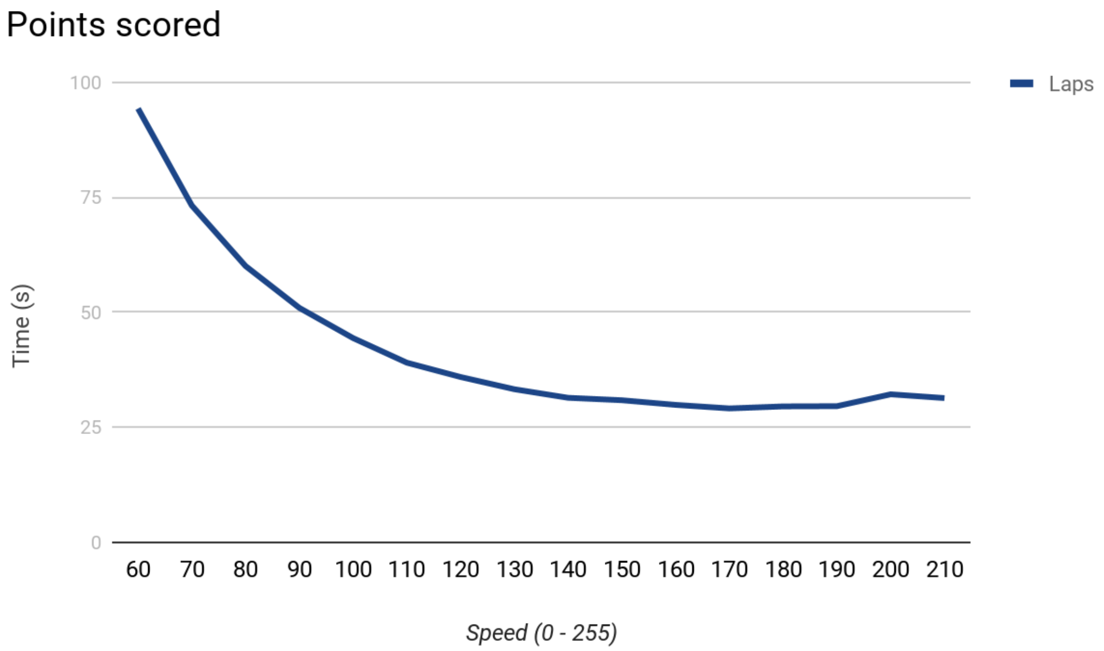

Figure 8. Time results through different Speed

4 Discussion

4.1 Flowchart and Turning Function

At the start of the project we had a problem with our flowcharts. We had a turn back functions which wasn't allowed. We solved it by changing it to "follow the junction" and added conditions for it to turn left or right depending where the junction is on the track.

After finishing the number of laps of the first clockwise direction, the rollbot must turn on the perpendicular starting line and navigate itself through another black line across the racing track which will make the rollbot move towards opposite direction. To achieve this, a "turning function" was added. The function should make the rollbot turn 90 degrees on to the starting line, follow it to the end and turn towards the opposite direction (anti-clockwise). Through testing the current "turning function" where the black line wasn't 90 degrees to the finish line it happened sometimes the rollbot would drive off track. This was the hardest part with the project to solve. Therefore, there was an inclusion of 2 more functions where the roll bot would turn on the black line above or below 90 degrees next to the finish line after finishing the number of laps required.

4.2 Observations of sensor study

We did different sensors testing under different environments. First thing we, discovered that each sensor reads a different value when placed on the same spot. After several tests on different conditions, the sensors were returning different values for all the sensors. As a result, all the infra-red sensors have different input which results to different output values. we can observe that when moving the sensors horizontally across the black line there is a positive correlation in the graph between the value of the sensors and the position of the sensors on the black line. However, sensor 4 at position 5 has different output values compared to the others (It's an anomaly). Maybe the sensor is bit severed compared to the other sensors. In conclusion the sensors don't have a perfect value output since every sensor reads different output data.

4.3 Observations of speed study

In this test the speed of the rollbot will be increased and the differences in behaviour will be noted. Different test was done at different speeds. The sensors do not only react differently under different environments, but also, they react under different motors speed. After through several speed tests on the rollbot, it would always drive off track at 220 motor speed. At 150 motor speed the four sensors start losing track of the line which resulted that the rollbot would start to drift left to right and vice versa due to constant misalignment of the sensors at high speed.
To solve this the maximum speed of the motors was decreased in steps until we got the optimum speed where the rollbot would drive as smooth as possible.

5 Conclusion

Through different sensors testing under different environments. First thing we, discovered that each sensor reads a different value when placed on the same spot. After several tests on different conditions, the sensors were returning different values for all the sensors.

It was also concluded after several speed tests on the rollbot, the faster the speed the faster it would finish a lap however it would always drive off track at 220 motor speed. At 150 motor speed the four sensors start losing track of the line which resulted that the rollbot would start to drift left to right and vice versa due to constant misalignment of the sensors at high speed.
To solve this the maximum speed of the motors was decreased in steps until we got the optimum speed where the rollbot would drive as smooth as possible.

Furthermore, the sensors weren't giving out the same output value, but the output was close. Maybe if the sensors had perfect readings the experiment results would be more accurate.

6 References

1) What is Arduino? (2017). https://www.arduino.cc/en/Guide/Introduction – 4/10/2017
2) What is different about the Sharp IR – Sensor?http://education.rec.ri.cmu.edu/content/electronics/boe/ir_sensor/4.html - 12/10/2017
3) How does the sensors function? https://www.google.se/search?q=how+does+the+sensors+in+a+rollbot+work&sa=X&biw=1536&bih=759&tbm=isch&source=iu&ictx=1&fir=JjWp5_yzO7lJ2M%253A%252CStiElSjQEmz18M%252C_&usg=__eJYkAlRqaLQhMHA1hZpV8ue9GuE%3D&ved=0ahUKEwi-spOgktLXAhVJCpoKHazyBEsQ9QEIMDAD#imgrc=JjWp5_yzO7lJ2M: - 30/10/2017

Appendices

Appendices typically include such elements as raw data, calculations, graphs pictures or tables that have not been included in the report itself. Each kind of item should be contained in a separate appendix. Make sure you refer to each appendix at least once in your report. [Arial 10p]

Appendix A

Sensor Testing Results

Table 2. Sensor 2.

	test 1	test 2	test 3	test 4	test 5	Average
Position 1:	80	80	79	80	79	79.6
Position 2:	85	85	86	85	86	85.4
Position 3:	245	244	244	245	246	244.8
Position 4:	485	484	484	485	485	484.6
Position 5:	483	484	485	484	485	484.2

Table 3. Sensor 3.

	test 1	test 2	test 3	test 4	test 5	Average
Position 1:	94	94	95	94	94	94.2
Position 2:	91	91	90	91	91	90.8
Position 3:	184	185	184	185	185	184.6
Position 4:	449	449	448	449	450	449
Position 5:	494	493	492	492	492	492.6

Table 4. Sensor 4.

	test 1	test 2	test 3	test 4	test 5	Average
Position 1:	98	99	99	98	99	98.6
Position 2:	100	101	100	101	102	100.8
Position 3:	324	323	323	324	324	323.6
Position 4:	552	552	551	551	551	551.4
Position 5:	580	581	580	580	581	580.4

Table 5. Sensor 5.

Sensor 5	test 1	test 2	test 3	test 4	test 5	Average
Position 1:	82	82	83	83	82	82.4
Position 2:	106	106	106	107	106	106.2
Position 3:	296	297	298	297	298	297.2
Position 4:	481	481	481	482	481	481.2
Position 5:	473	473	472	473	473	472.8

Appendix B

Code for black line navigation

```
#include "Rollbot.h"

RollbotReadSensor Sensor;
RollbotMotors Motor;
int Speed_Dir = 0;
int BASE_SPEED = 100;
int blackthreshold = 160;
int clockwise = 1;
int c_clockwise = 1;
int count = 0;
int turnflag = 0;
void setup() {
}
void loop() {
  // put your main code here, to run repeatedly:
Sensor.Read_Data();
// go straight
if ((Sensor.data[0] > blackthreshold) && (Sensor.data[1] > blackthreshold) &&
(Sensor.data[2] < blackthreshold) && (Sensor.data[3] > blackthreshold) && (Sensor.data[4]
> blackthreshold))
{
  Motor.Motordrive(Speed_Dir, BASE_SPEED, BASE_SPEED);
}
//start line
else if((Sensor.data[0] < blackthreshold) && (Sensor.data[1] < blackthreshold) &&
(Sensor.data[2] < blackthreshold) && (Sensor.data[3] < blackthreshold) && (Sensor.data[4]
< blackthreshold))
{
  delay(90);
  count++;
  if ((count == (clockwise+1)) && (turnflag == 0))
 {
   Motor.Motordrive(Speed_Dir, BASE_SPEED ,  -50);
   turnflag = 1;
   delay(500);
```

```
  }
  else if(turnflag == 1)
  {
    Motor.Motordrive(Speed_Dir, 0 , BASE_SPEED);
    turnflag = 0;
    count--;
    delay(500);
  }
  else if(count == (clockwise+c_clockwise+1))
 {
    Motor.Motordrive(Speed_Dir, 0 , 0);
    BASE_SPEED = 0;
 }
 else
 {
  Motor.Motordrive(Speed_Dir, BASE_SPEED, BASE_SPEED);
 }
}
else if ((turnflag == 1)&&((Sensor.data[0] < blackthreshold) && (Sensor.data[1] <
blackthreshold) && (Sensor.data[2] < blackthreshold)))
{
  Motor.Motordrive(Speed_Dir,-50 , BASE_SPEED);
  turnflag = 0;
  delay(500);
}
else if ((turnflag == 1)&&((Sensor.data[2] < blackthreshold) && (Sensor.data[3] <
blackthreshold) && (Sensor.data[4] < blackthreshold)))
{
  Motor.Motordrive(Speed_Dir, -50 , BASE_SPEED-20);
  turnflag = 0;
  delay(100);
}
// turn left
else if (((Sensor.data[0] < blackthreshold)||(Sensor.data[1] < blackthreshold)) &&
(Sensor.data[2] > blackthreshold))
{
  Motor.Motordrive(Speed_Dir, 40 , BASE_SPEED);
}
// turn right
```

```
else if (((Sensor.data[3] < blackthreshold)||(Sensor.data[4] < blackthreshold)) &&
(Sensor.data[2] > blackthreshold))
{
 /* if (((Sensor.data[0] > blackthreshold) && (Sensor.data[1] < blackthreshold)) &&
(Sensor.data[2] < blackthreshold) && (Sensor.data[3] < blackthreshold) && (Sensor.data[4]
< blackthreshold))
  {
    Motor.Motordrive(Speed_Dir, BASE_SPEED , BASE_SPEED);
  }*/
  Motor.Motordrive(Speed_Dir, BASE_SPEED ,  40);
}
}
```

Appendix C

Logbook

21st September 2017

- Today we gathered to figure out how to draw the flowchart. We decided that everyone of us to draw our own flowchart and combine them together to get the best possible flowchart that will work.

22nd September 2017

- We brought our flowchart and designed the flowchart which we wanted to put it on the report.

18th November 2017

- Today we were going to test the sensors which the teacher wanted from us. One of us decided to write the code for the test. When that was done we decided that all of us should test the sensors at home and test it as much ass possible so tat we could get a proper understanding how the sensors work, and the test would be more reliable.

19th November 2017

- When all of us brought the results. We made graphs and tables of the results

22nd November

- There had been some misunderstanding on deadline between the teachers therefore we had to submit the report as soon as possible if we could. So today we just put a lot of effort on the report with editing and fine adjustment.

28th November

- Today we did a lot of editing with the report to make it more readable, and professional. We also wrote the code for the rollbot so that it can follow the line.

11th December

- We tested the car on the new and the final circuit. And adjusted the code so it could turn at the conjunction to go anticlockwise.

12th December

- Today we just did the final touches with the report