UFMFCA-15-1

Practical Electronics

Self-Navigating line Tracer Robot (LTR)

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Introduction:

This project aims to create a self-navigating line tracer robot which moves and follows only a line without using a microcontroller. Therefore, it also aims to make a motor driver, two IR sensors, and the robot car chassis.

To do this project some research was done by using Google and YouTube. From this research, it was understandable that to do this project, a motor driver, two IR sensors, and a robot car chassis are needed *(Tapendra Mandal, 2017; 4 MAD BOYS, 2020).*

A single IR sensor consists of a TCRT5000 reflective IR sensor, a 10kΩ resistor, a 220Ω resistor, and an LED (a blue LED IS used for this project). The TCRT5000 is an electrical component that consists of the transmitter T_X (photodiode) and a receiver R_X (phototransistor). As shown in Figure 1, the photodiode has two pins (cathode (-) and anode (+)), and the phototransistor has two pins (emitter and collector) *Anon. (2021).*

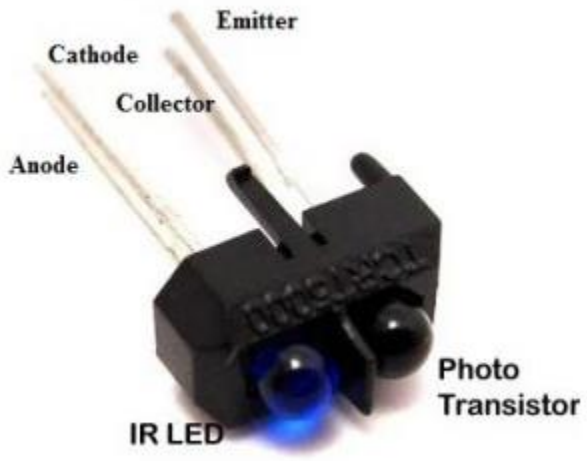

Figure 1: TCRT5000 configuration *Anon. (2021).*

The photodiode of the TCRT5000 transmitting infrared light, and the phototransistor will receive it depending if there is an object in front of the TCRT5000 or not, also depending on the color of the object (black objects absorb the infrared light and white objects do the opposite). Therefore, when the phototransistor receives the infrared light, current pass between emitter and collector (*DIY Machines, 2019)*.

The motor driver circuit of this project consists of a switch, the LM7805 voltage regulator, two motors (with wheels), two IR sensors, and the main component is the L293D IC, which is also known as the L293D motor driver IC. This IC is used to drive motors, and it consists of 16 pins (as shown in Figure 2) *Anon. (2017).*

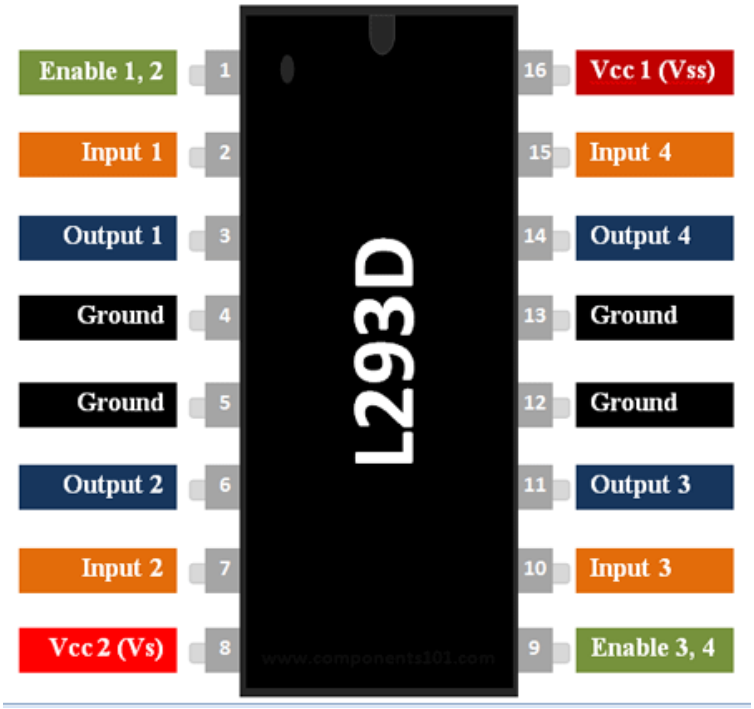

Figure 2: The pinout of the L293D motor driver IC *Anon. (2017).*

Design:

- ***The components of this project:***
  - Two TCRT5000
  - Two blue LED
  - Two 10kΩ resistor
  - Two 220Ω resistor
  - 3 pieces of PCB
  - Six pieces of 3 pins of the Female header
  - L293D
  - LM7805
  - A switch
  - Two motors
  - Two wheels
  - A metal ball caster free wheel
  - 9V battery
  - A breadboard
  - Wires
  - Two screw terminals (two pins)
  - A carton
  - Soldering tools
  - Black tape
  - Glue gun and its sticks

- ***Calculations:***

  - The minimum supply voltage V_{CC1} in L293D is 4.5V and the maximum supply voltage is 7V (*Texas Instruments, 2012)*.
  - The minimum supply voltage V_{CC2} in L293D is V_{CC1} and the maximum supply voltage is 36V (*Texas Instruments, 2012)*.
  - The minimum input voltage for LM7805 is 7V and the maximum input voltage is 25V (*Texas Instruments, 2004)*.
  - The output voltage for LM7805 in +5V (*Texas Instruments, 2004)*.
  - The typical supply voltage for TCRT5000 is 3.3V or 5V *Anon. (2019)*.

  LM7805 was included in the project's circuit because it gives +5V V_{out} to supply it to the project's circuit. Therefore, it's suitable for L293D and TCRT5000. Moreover, because the minimum V_{in} for LM7805 and the maximum V_{in} is 25V, the 9V battery was the best choice for this project compared to the other batteries that were available.

- ***The IR sensor circuit diagram:***

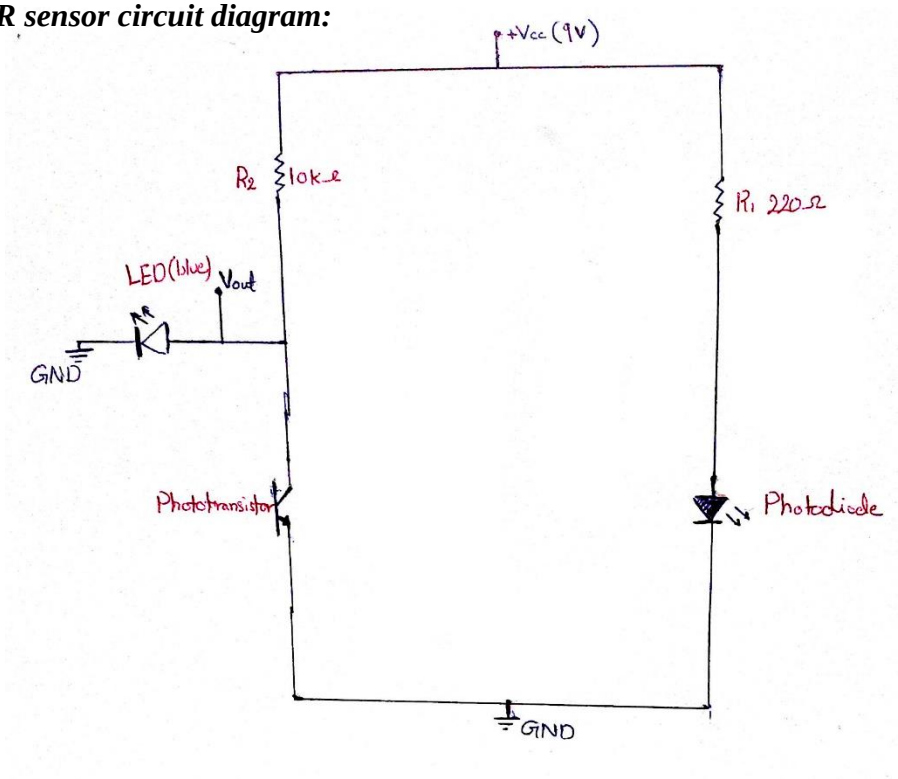

Figure 3: The circuit diagram of an IR sensor.

- ***Constructing the IR sensor circuit in breadboard:***

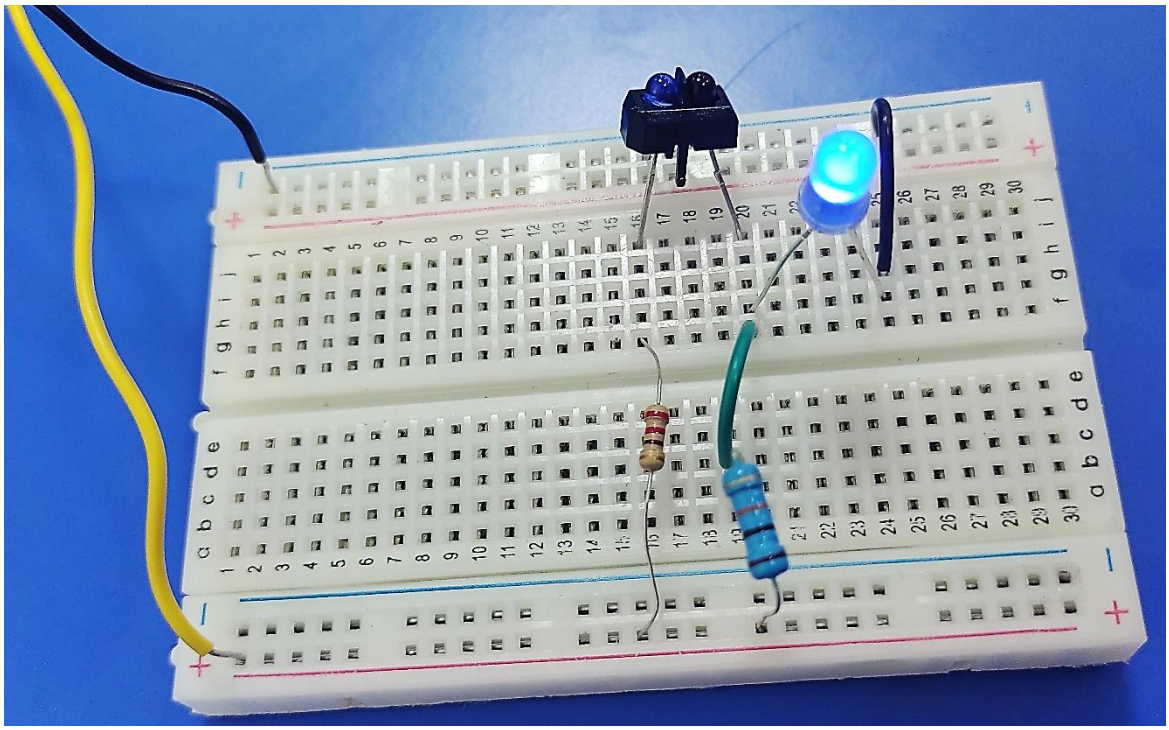

Figure 4: The IR sensor circuit in breadboard.

- ***The solder of the IR sensors:***

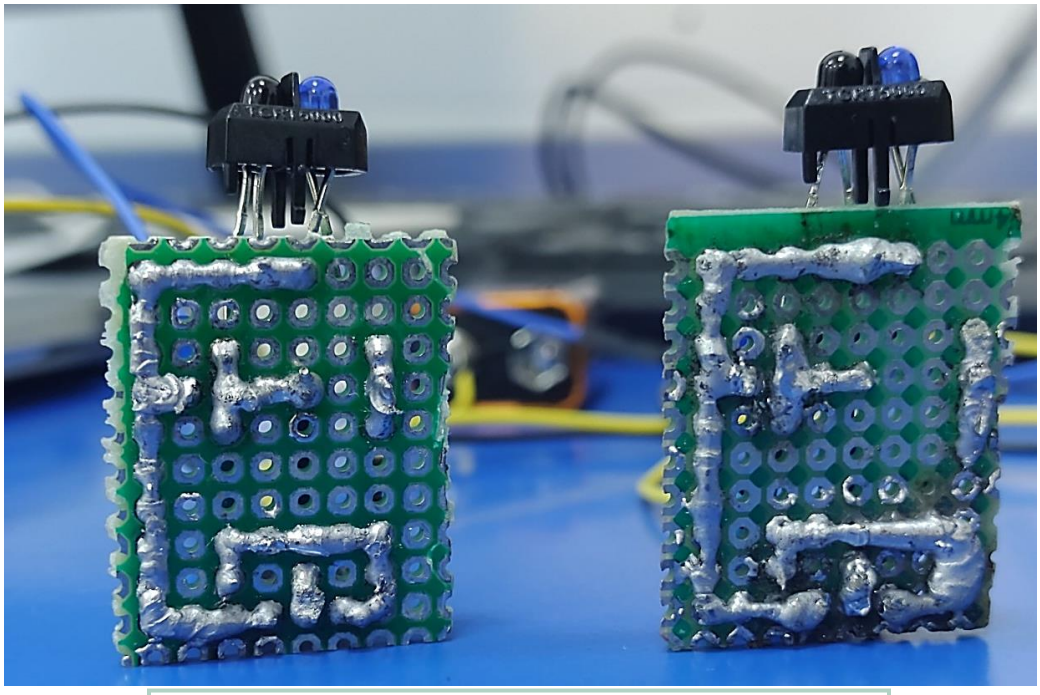

Figure 5: The solder of both IR sensors on two PCBs.

- ***The IR sensors on PCB:***

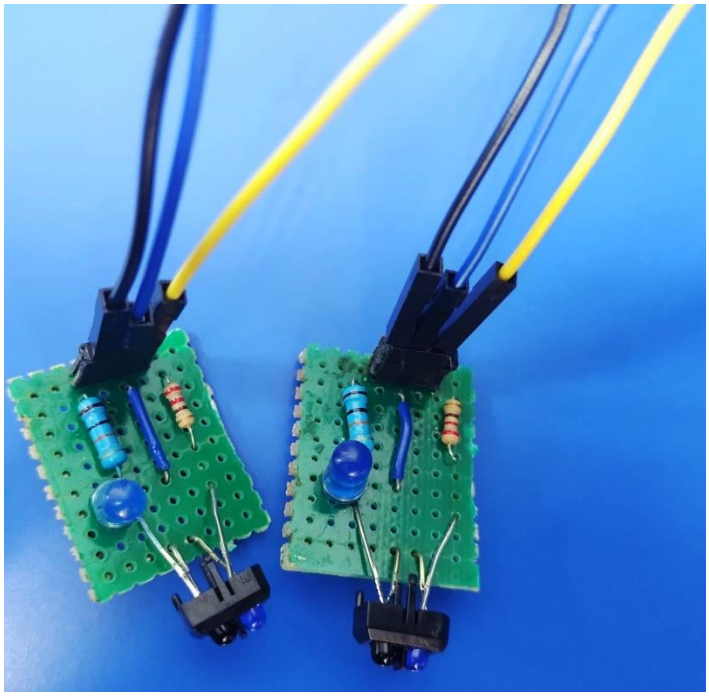

Figure 6: The two IR sensors of this project on two PCBs.

- ***The motor driver circuit diagram:***

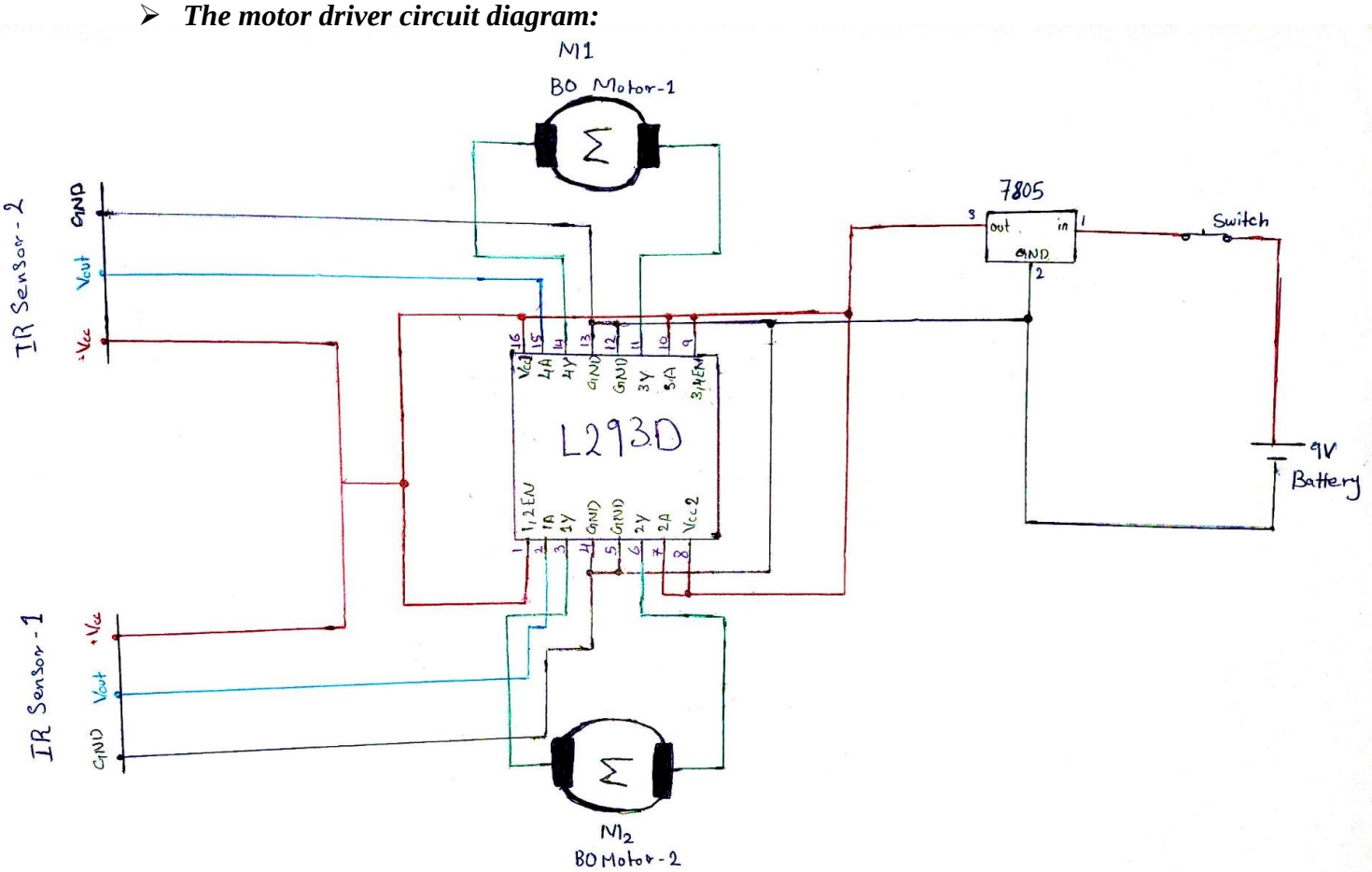

Figure 7: The circuit diagram of the motor driver.

- ***Constructing the motor driver circuit by using breadboard:***

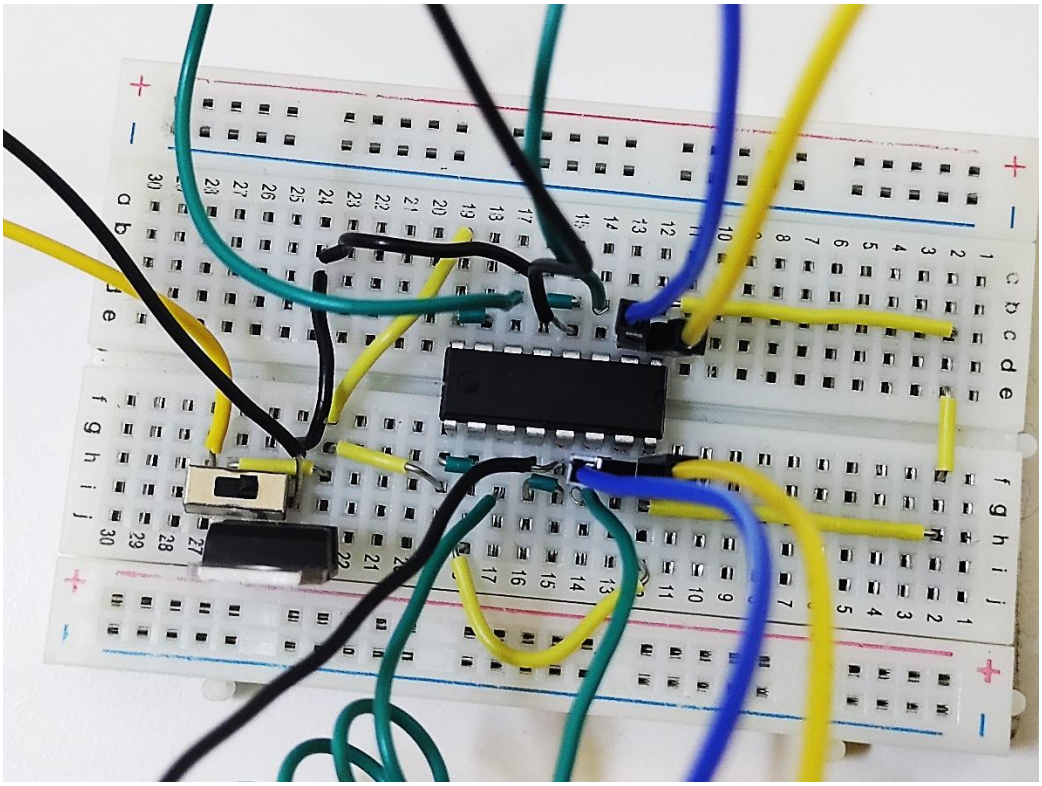

Figure 8: The motor driver circuit constructed in the breadboard.

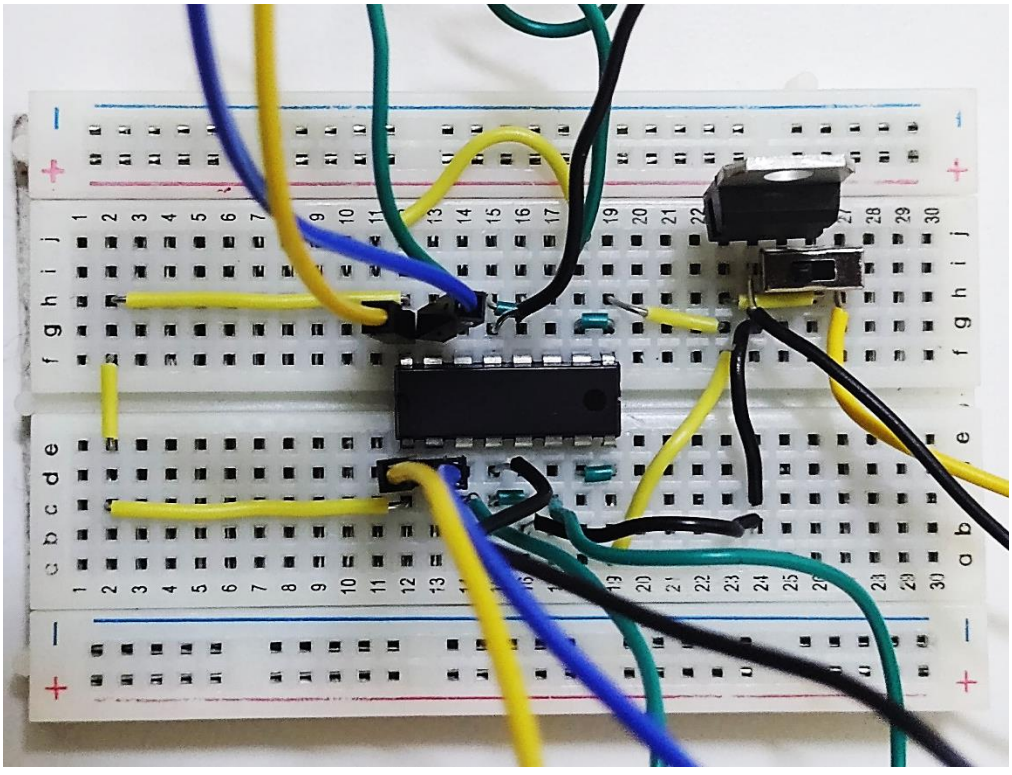

Figure 9: Another picture of the motor driver circuit constructed in the breadboard.

- ***The solder of the motor driver:***

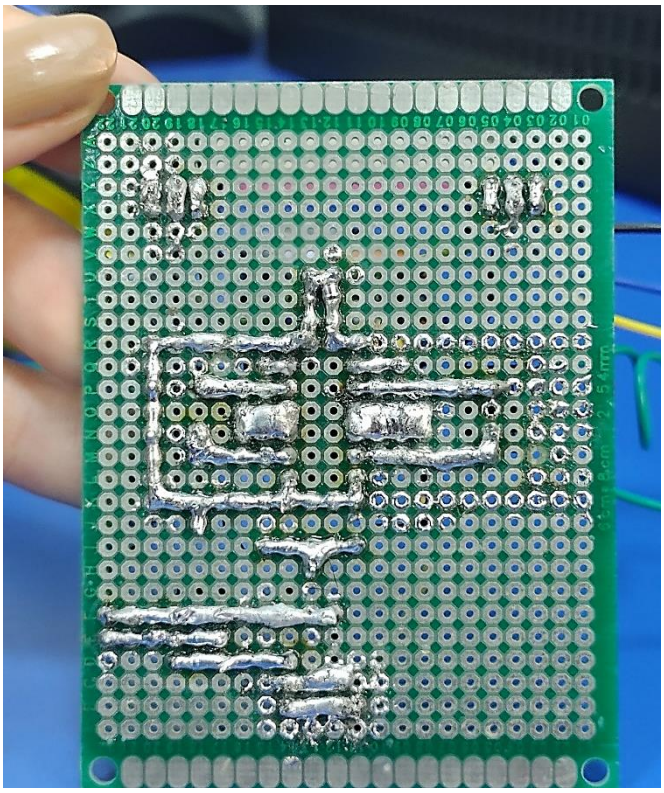

Figure 10: The solder of the motor driver on a PCB.

- ***The motor driver on PCB:***

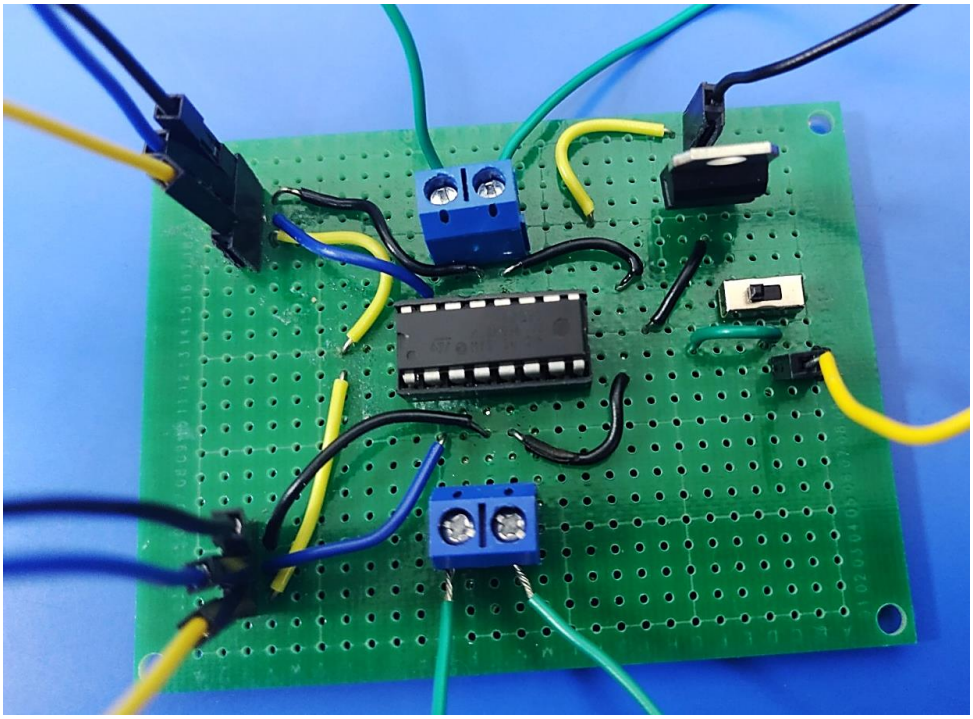

Figure 11: The motor driver of this project on a PCB.

- ***The final design of the LTR:***

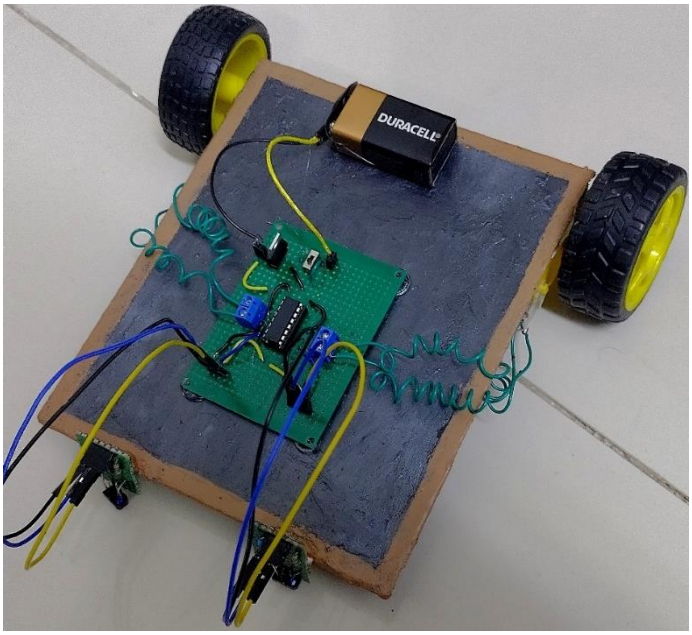

Figure 12: The LTR final design.

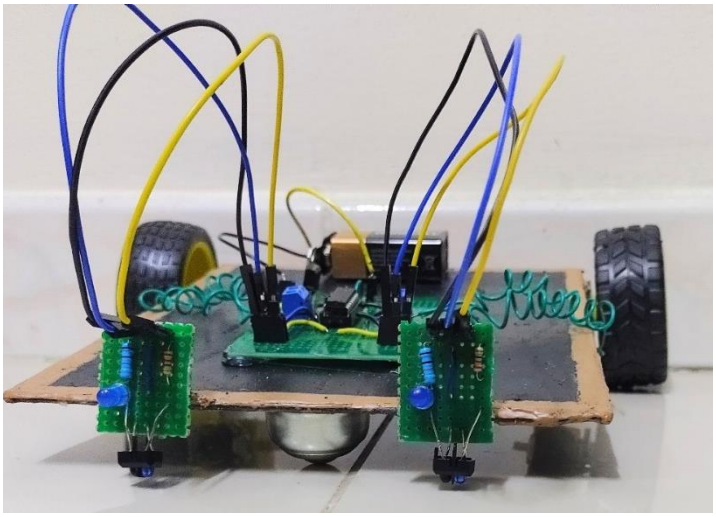

Figure 13: Another picture for the LTR final design.

- ***Recommended improvements on the design:***

  - Make a ready-made module for the project's circuit on a single PCB.
  - Use a ready-made robot car chassis.
  - Make the whole design in 3D printing.

Results:

- ***Testing the IR sensor in a breadboard:***

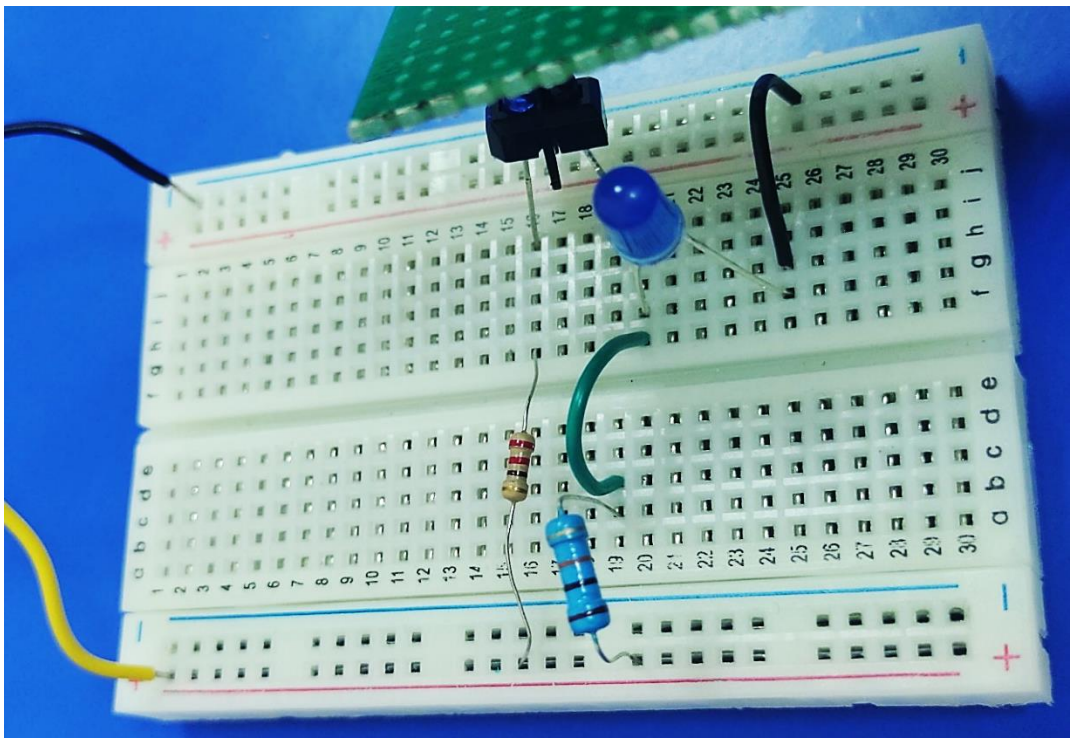

Figure 14: The LED of the IR sensor don't light when there is a green object (not black) in front of TCRT5000.

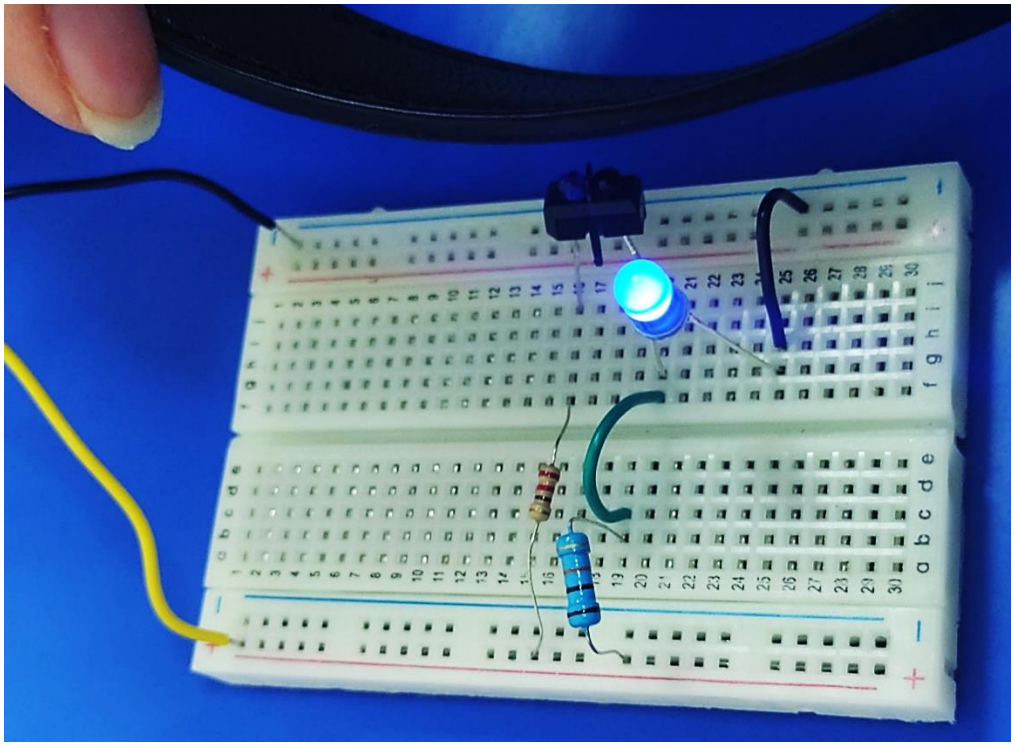

Figure 15: The LED of the IR sensor lights when there is a black object in front of TCRT5000.

- ***Testing the first IR sensor after soldering:***

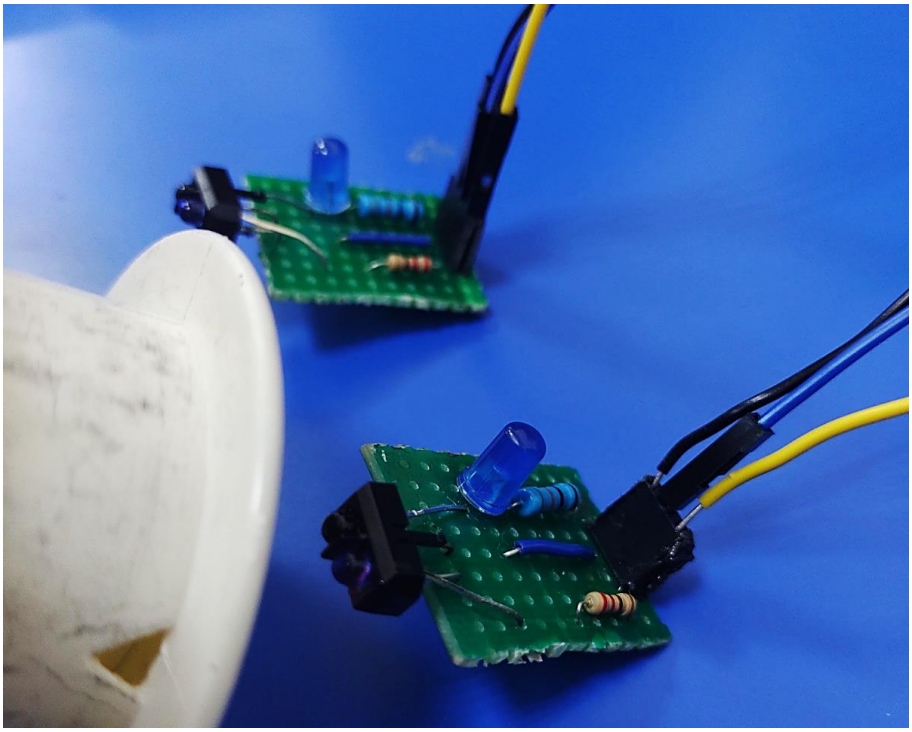

Figure 16: The LED of the IR sensor don't light when there is a white object (not black) in front of TCRT5000.

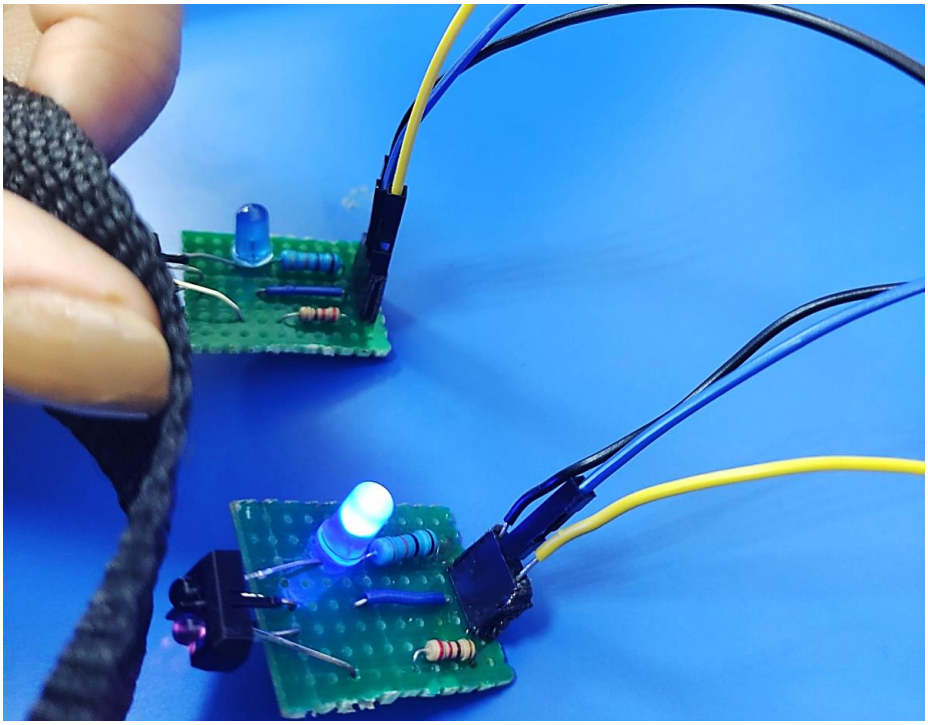

Figure 17: The LED of the IR sensor lights when there is a black object in front of TCRT5000.

- ***Testing the second IR sensor after soldering:***

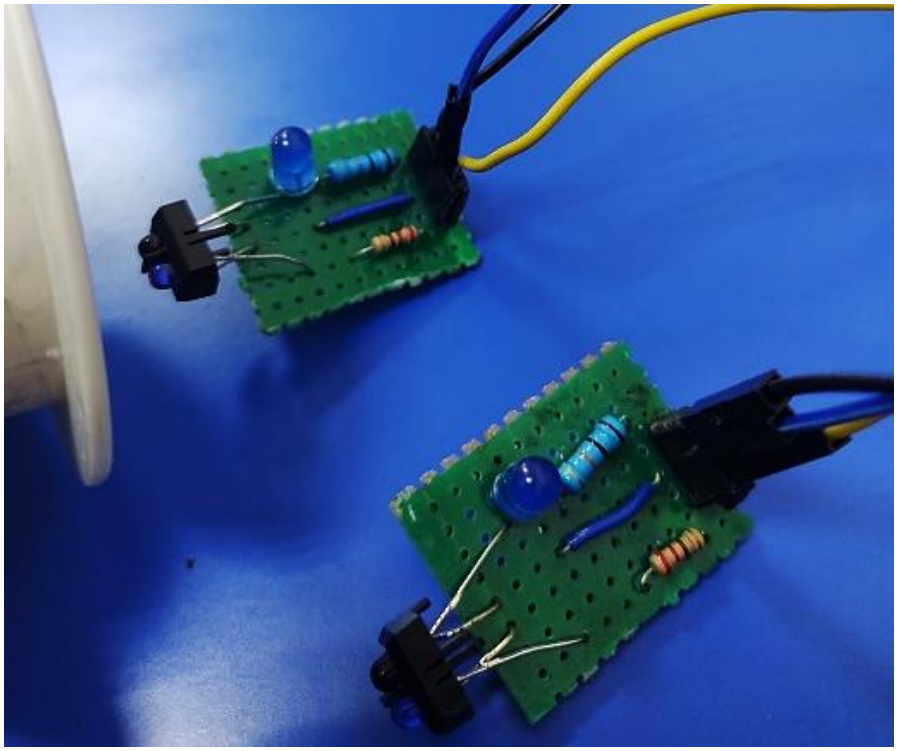

Figure 18: The LED of the IR sensor don't light when there is a white object (not black) in front of TCRT5000.

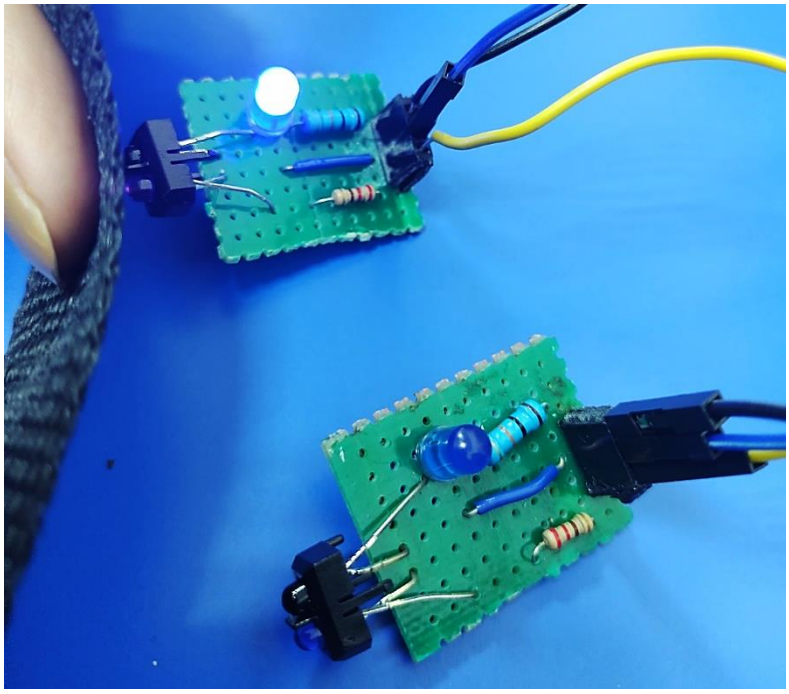

Figure 19: The LED of the IR sensor lights when there is a black object in front of TCRT5000.

- ***Testing the motor driver circuit in breadboard:***

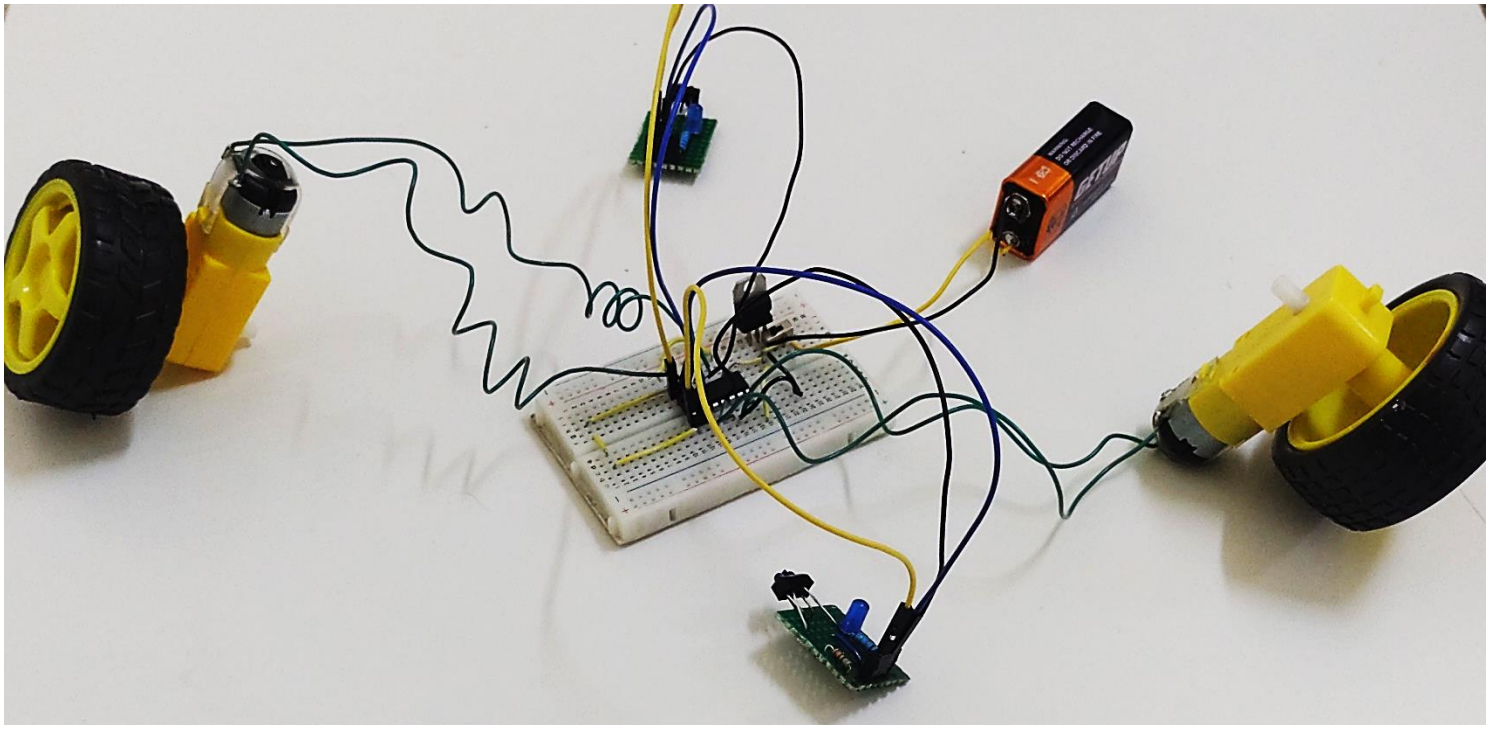

Figure 20: The project's circuit when the motor driver's switch is off.

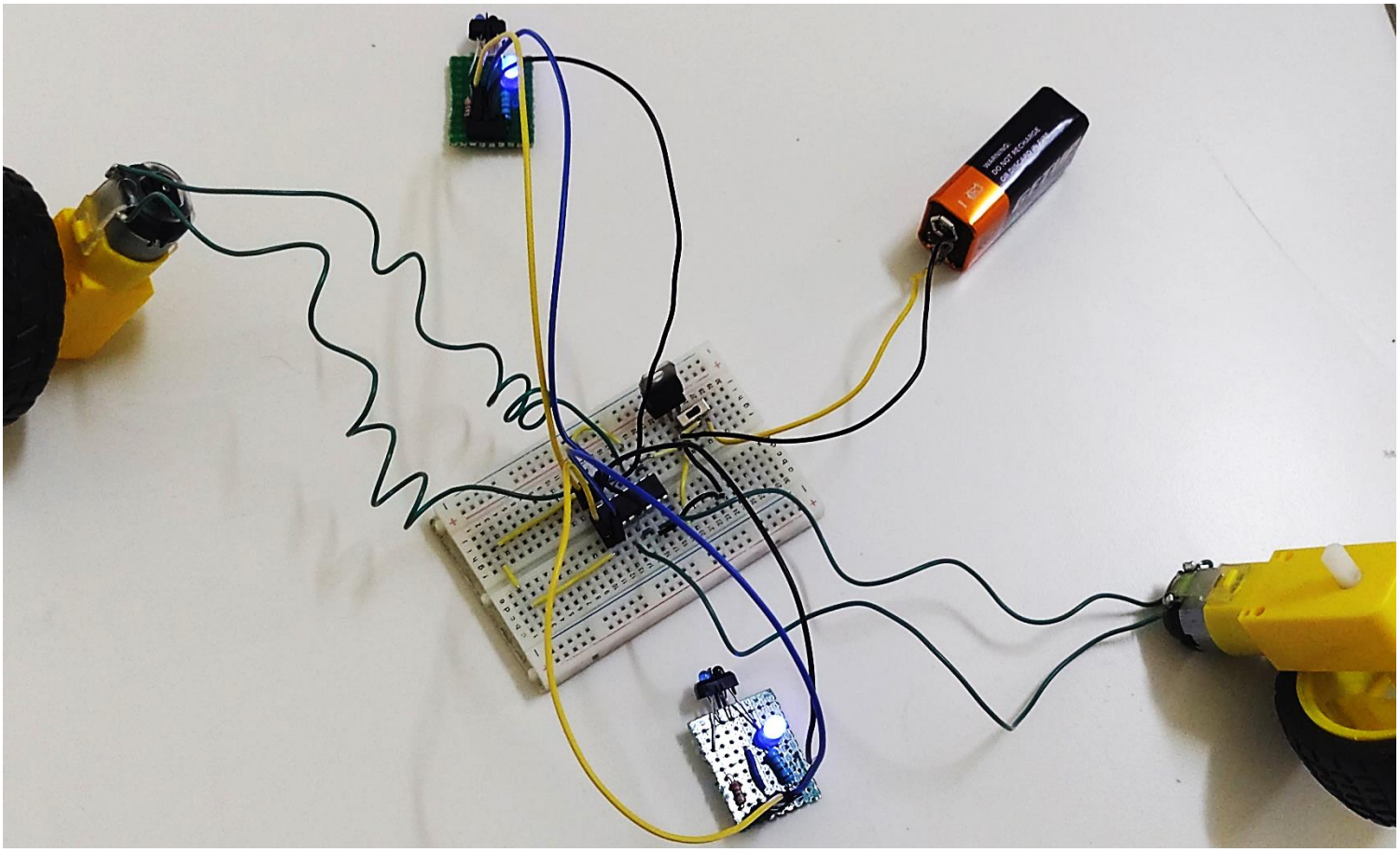

Figure 21: The project's circuit when motor driver's switch is on.

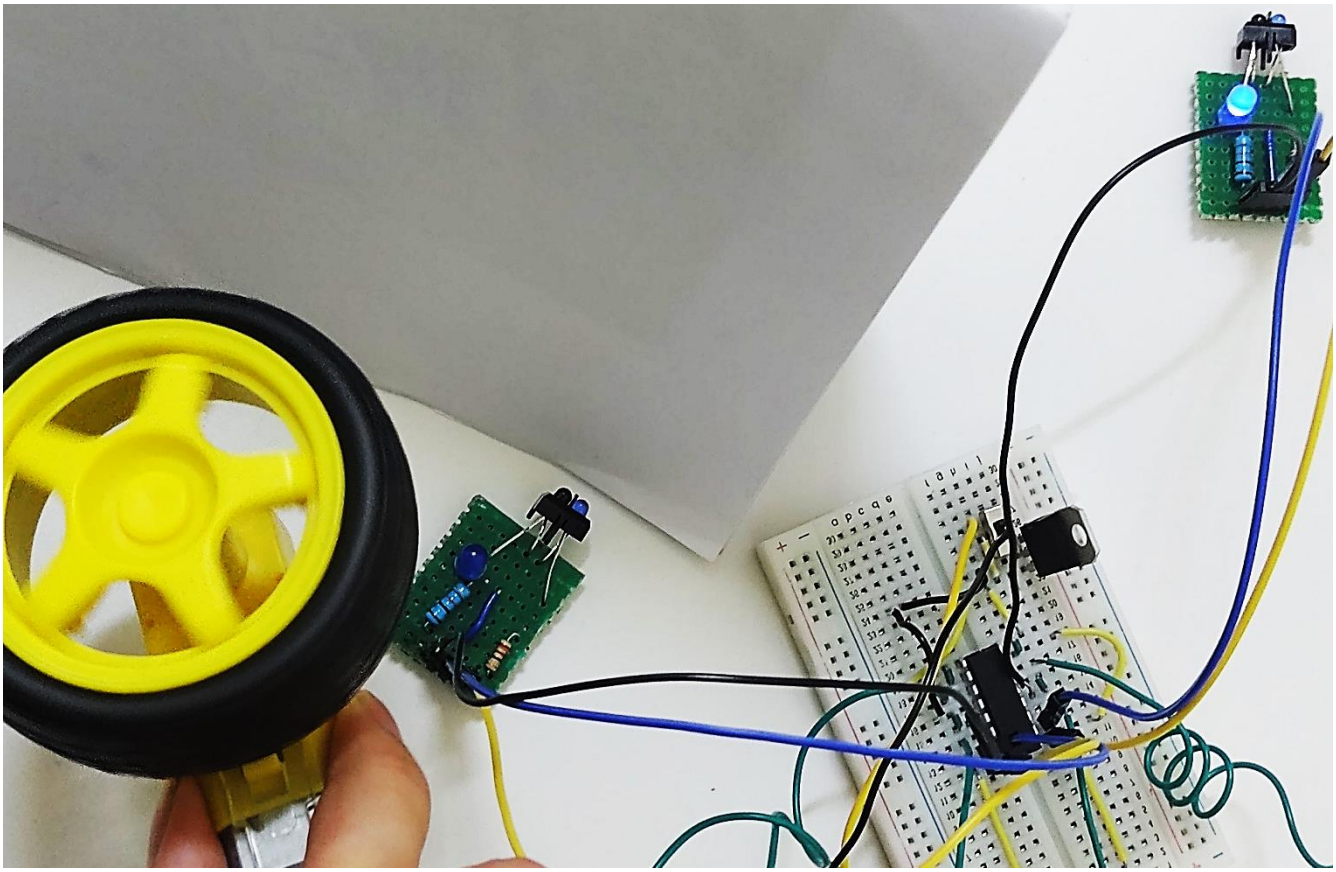

Figure 22: The left wheel works when a white object is in front of the left IR sensor.

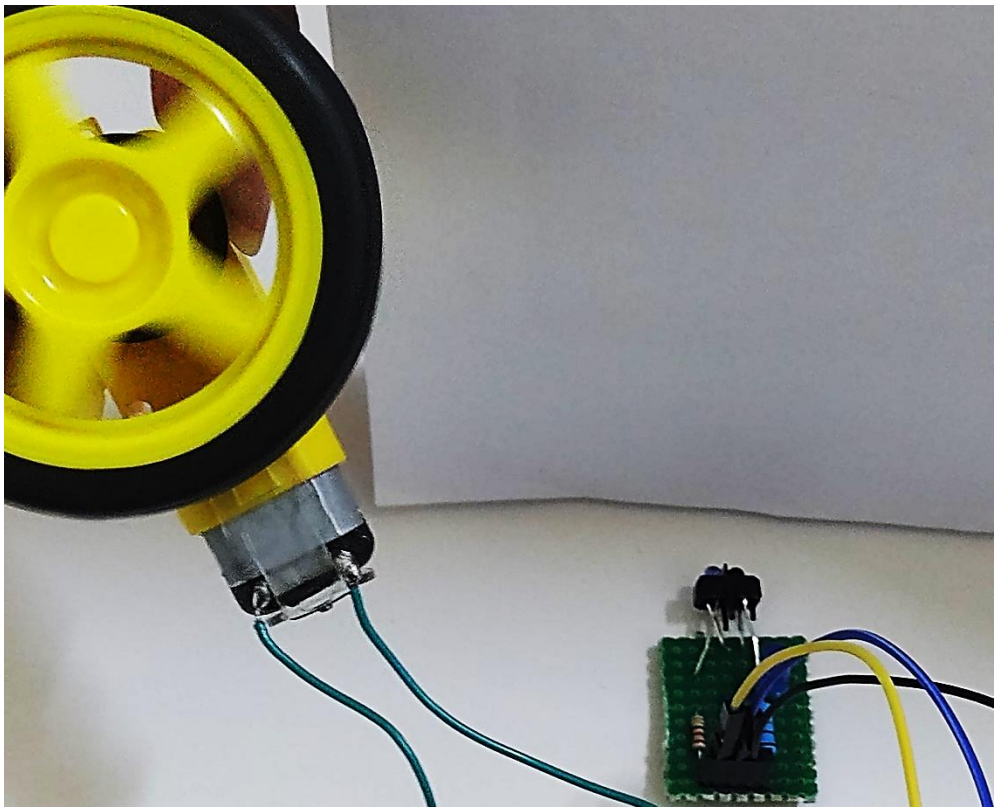

Figure 23: The right wheel works when a white object is in front of the right IR sensor.

- ***Testing the motor driver circuit after soldering:***

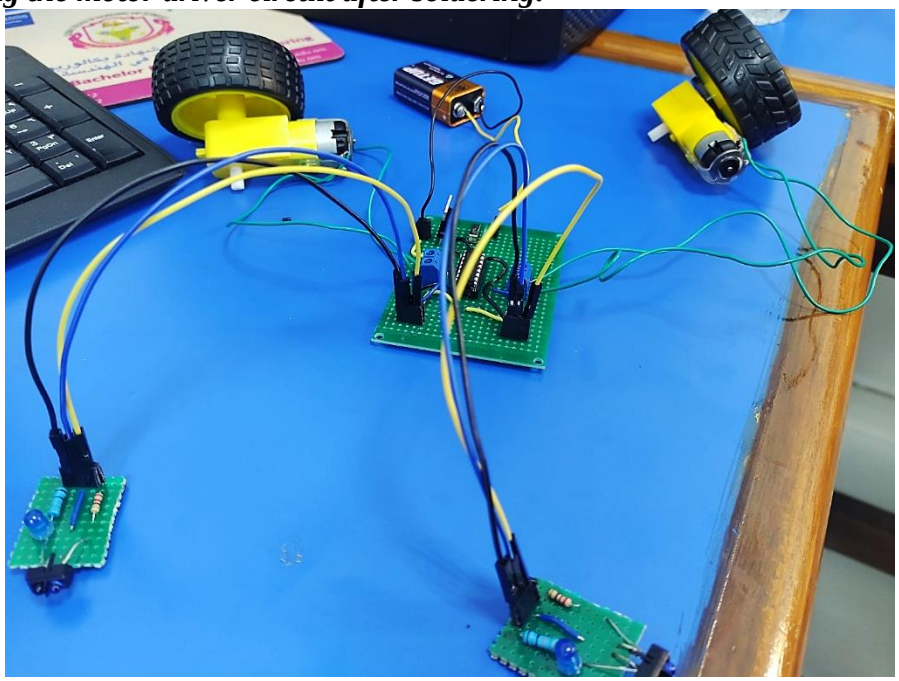

Figure 24: The project's circuit when the motor driver's switch is off.

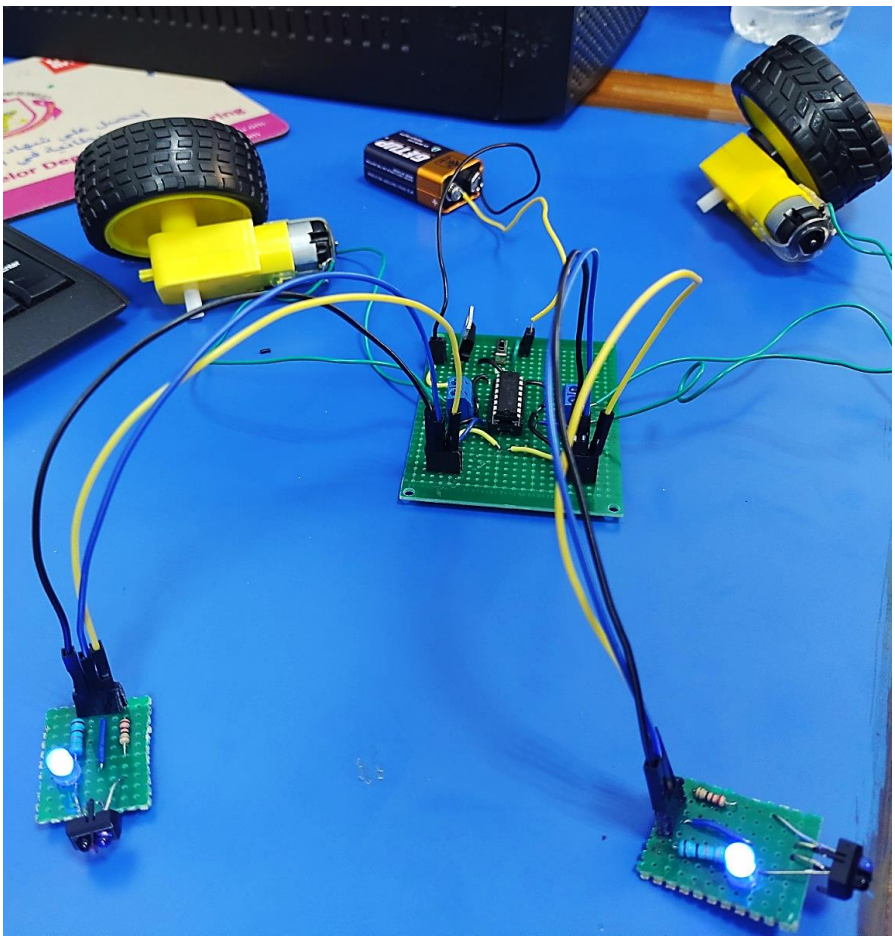

Figure 25: The project's circuit when the motor driver's switch is on.

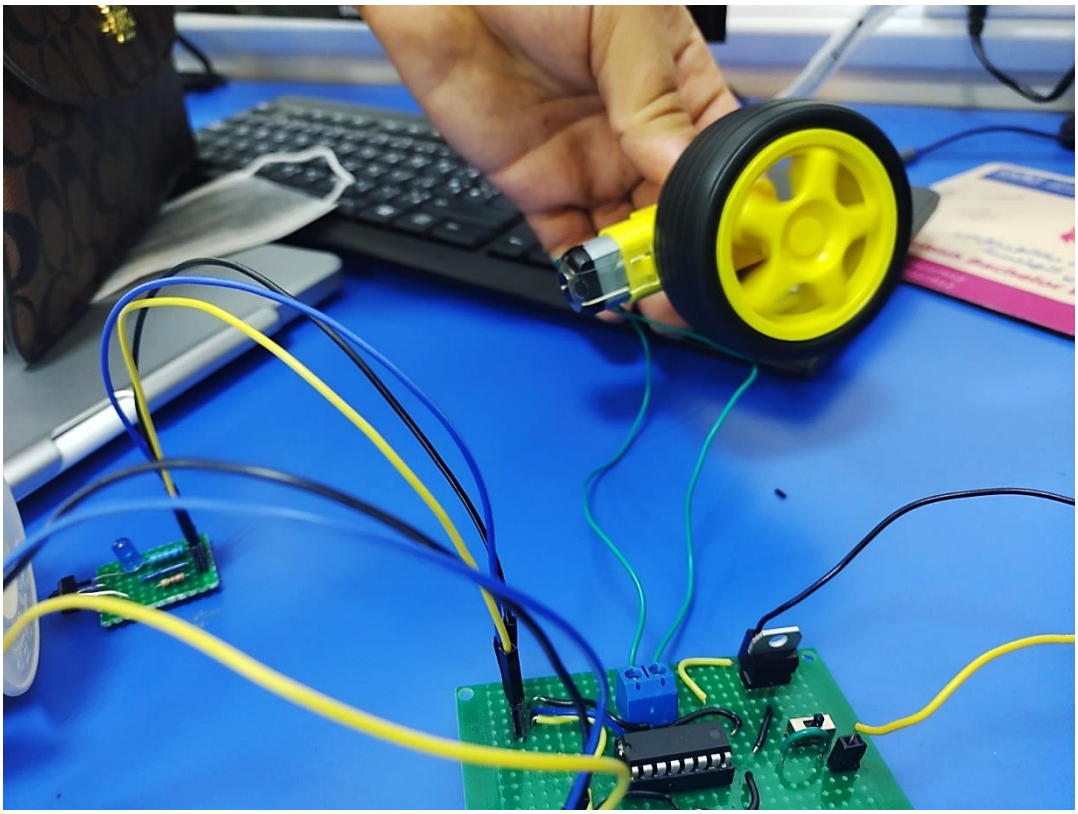

Figure 26: The left wheel works when a white object is in front of the left IR sensor.

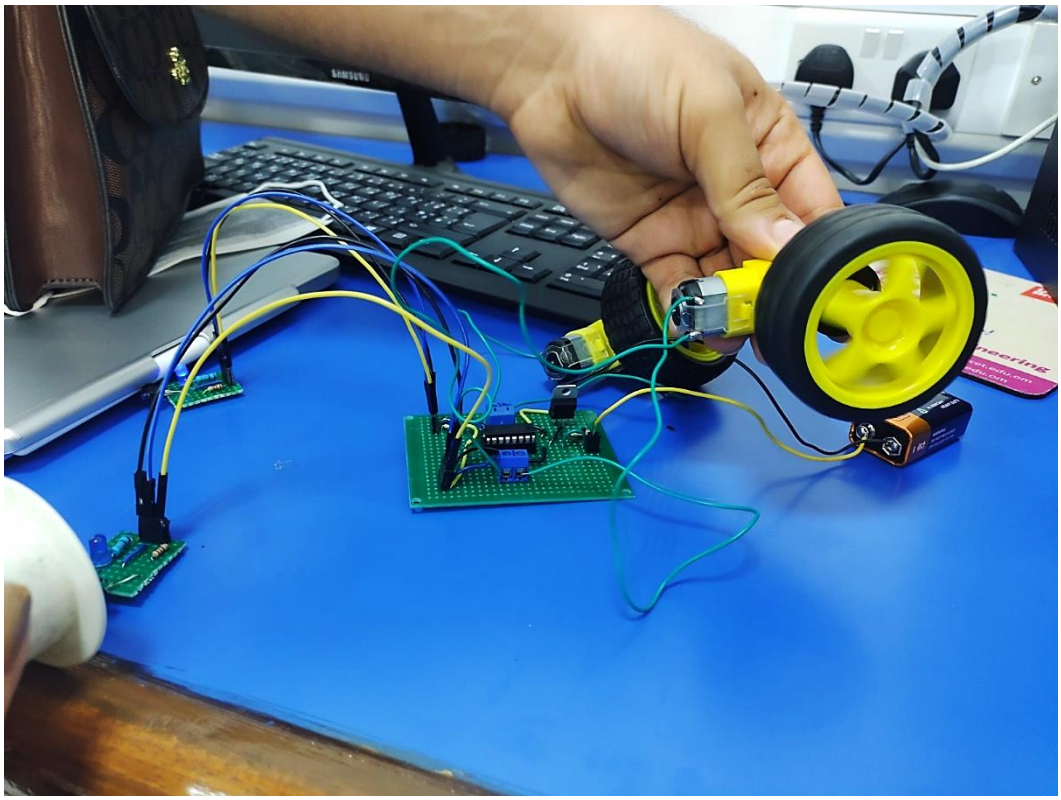

Figure 27: The right wheel works when a white object is in front of the right IR sensor.

- ***Testing the LTR project after finishing it:***

  - *A video:*

    ..\Videos\LTR Project.mp4

  - *Some pictures:*

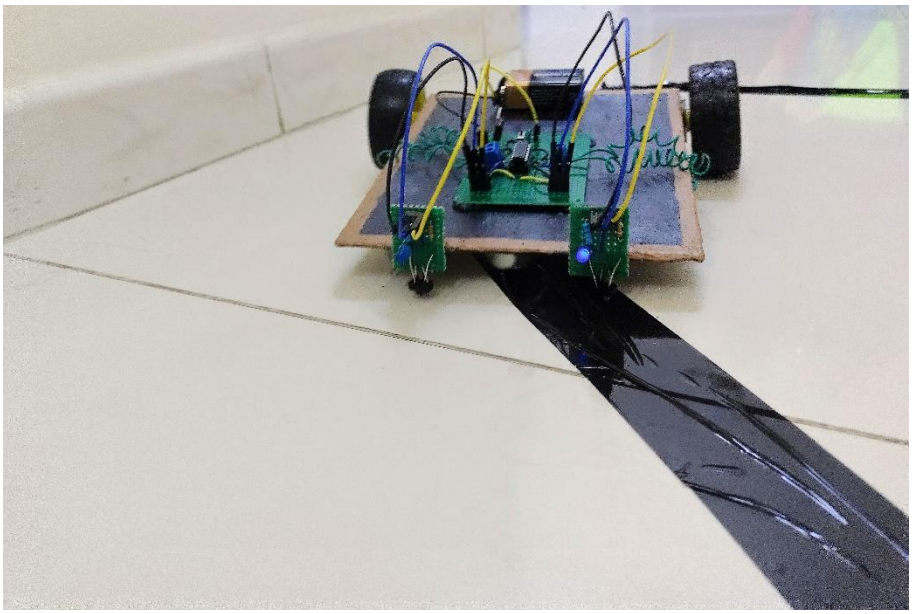

Figure 28: Testing LTR.

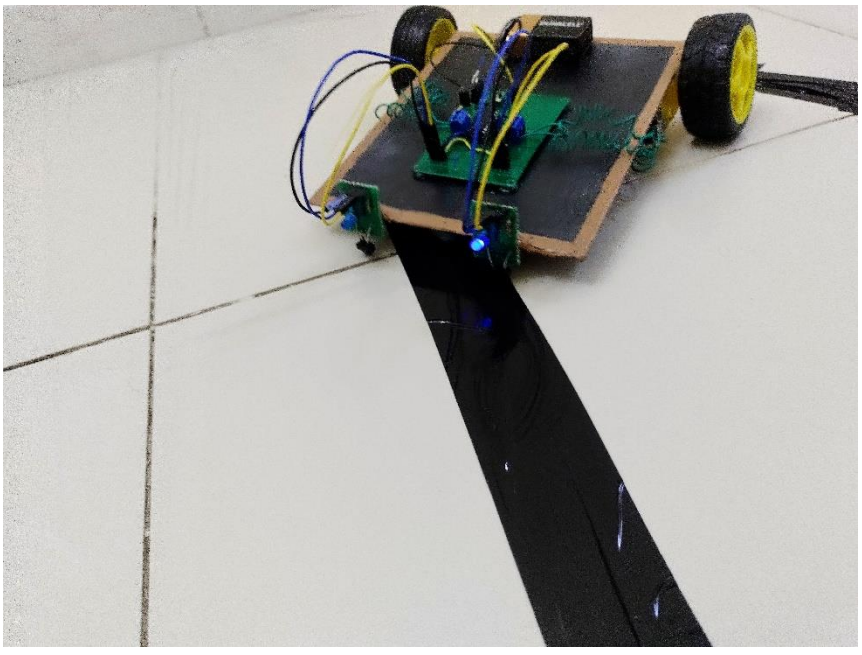

Figure 29: Another picture testing LTR.

Discussion and Reflection:

This project is mainly consisting of the motor driver and two IR sensors. There were two circuit designs proposed for each one. For the IR sensor circuit, the first circuit diagram that was proposed is shown in Figure 30, and the second one is shown in Figure 3. The second one was chosen because it worked in the breadboard unlike the first one. For the motor driver circuit, the first circuit diagram that was proposed is shown in Figure 31, and the second circuit diagram is shown in Figure 7. The second circuit was chosen because the first circuit will take more time in soldering.

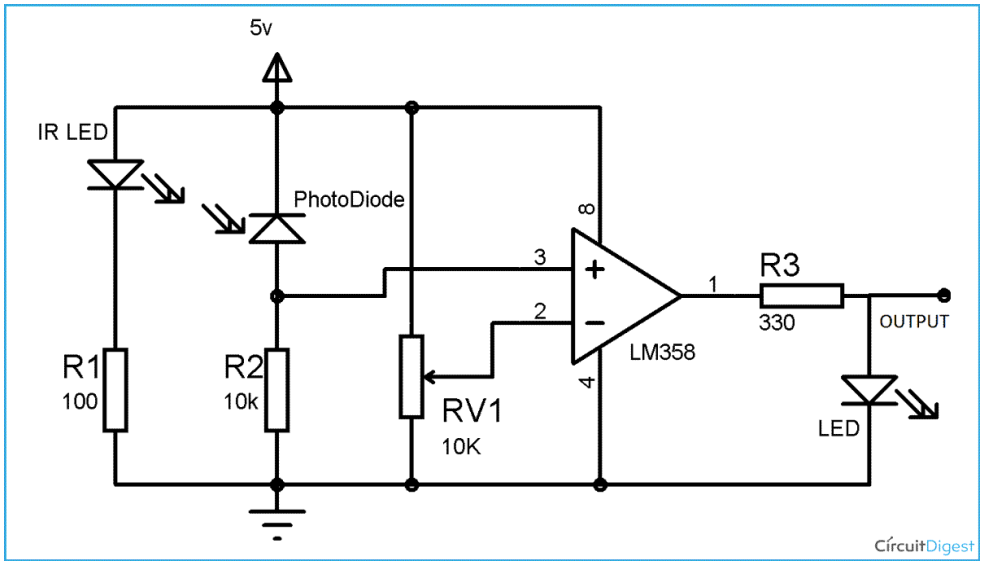

Figure 30: A second IR sensor circuit diagram (*Jayant, 2015)*.

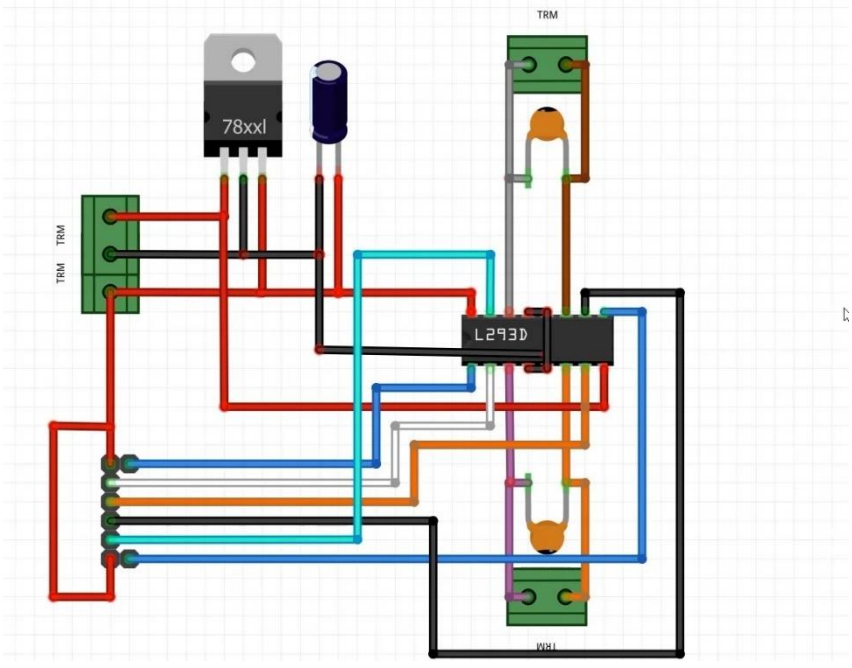

Figure 31: A second motor driver circuit diagram (*4 MAD BOYS, 2020)*.

From the results, it is clear that the LTR works, where in the last test (as shown in Figure 28, Figure 29 and the video) when the black line becomes in front of one of the IR sensors, it will make the wheel that is connected to it stop working, so the wheels only move on the white, and this is how the project works.

Moreover, some problems occurred while doing this project. For instance, while soldering the first IR sensor, some uncoated wires were used, so the sensor didn't work, and then they were removed to solve this problem. Moreover, while testing the motor driver after soldering, the IR sensors were working, but the wheels weren't working because the battery was about to die (was about 3V), therefore, the battery was changed to a new one. Finally, while testing the LTR after finishing it, it was moving slowly. Therefore, the battery was changed to a one that has a better quality.

This project improves some skills and strengths. For instance, learning how to solder for the first time, learning how to use the breadboard better than before, learning about new components, and some communication skills were gained because this project requires to communicate for asking and getting information. Due to these improvements, doing other projects in the coming years will be much easier.

Conclusions:

To conclude, this LTR project was done without using a microcontroller and by mainly making two IR sensor and a motor driver. It was done and worked successfully (as shown in the results). Where it was tested many times in different ways (testing by using the breadboard, testing after soldering, and testing after finishing) and it worked well. Finally, this project was challenging because it's the first time to work practically to make a robot, also some problems occurred (as mentioned in the discussion). However, it was interesting and beneficial.

References:

- ***Tapendra Mandal (2017) How to Make a Line Following Robot without Microcontroller. YouTube [video]. 03 March. Available from: https://youtu.be/ZQjmUt3_ffM [Accessed 8 April 2022].***

- ***4 MAD BOYS (2020) How to make line follower without microcontroller. YouTube [video]. 02 November. Available from: https://youtu.be/nK_y9cnyppQ [Accessed 8 April 2022].***

- ***4 MAD BOYS (2020) circuit. Available from: https://drive.google.com/file/d/1u1bmI_WOVj4JCZUODB1bWt3zFxylI4Nn/view [Accessed 8 April 2022].***

- ***Jayant (2015) IR Sensor Circuit Diagram. Available from: https://circuitdigest.com/electronic-circuits/ir-sensor-circuit-diagram [Accessed 8 April 2022].***

- ***Anon (2021) TCRT5000 IR Sensor : Pin Configuration & Its Applications. Available from: https://www.elprocus.com/tcrt5000-ir-sensor/ [Accessed 10 April 2022].***
- ***DIY Machines (2019) TCRT5000 Infrared Reflective Sensor - How It Works and Example Circuit With Code. Available from: https://www.instructables.com/TCRT5000-Infrared-Reflective-Sensor-How-It-Works-a/ [Accessed 10 April 2022].***
- ***Anon (2017) L293D Motor Driver IC. Available from: https://components101.com/ics/l293d-pinout-features-datasheet [Accessed 11 April 2022].***
- ***Texas Instruments (2012) Quadruple Half-H Drivers (Rev. C). Available from: https://cdn-shop.adafruit.com/datasheets/l293d.pdf [Accessed 20 May 2022].***
- ***Texas Instruments (2004) uA7800 Series (Rev. J). Available from: https://www.sparkfun.com/datasheets/Components/LM7805.pdf [Accessed 20 May 2022].***
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