

**MAE/ECE 5320 Mechatronics
2025 Spring
Final Project Report**

Light Follower Robot

Submitted by

Team members:

Kaden Gordon, A02368773

Sam Morrill, A02346742

Henry Riker, A02205299

Anna Von Niederhausern, A02268163

Contents

Section 1. Project abstract.....	3
Section 2. Team members and contributions.....	3
Section 3. Project description.....	3
Section 4. Results.....	6
Section 5. Conclusions.....	6
Section 6. References.....	6

Section 1. Project abstract

The students' selected project is a Light-Following Robot (LFR). Photosensors feed the directional input into the arduino and the rover corrects its direction to follow the light. The translation of light sensing to direction of travel is done by a PID controller. A distance sensor primarily controls the speed of the LFR based on distance to the nearest obstacle. The closer the obstacle, the slower the LFR moves, when the obstacle is close enough, the LFR comes to a complete stop.

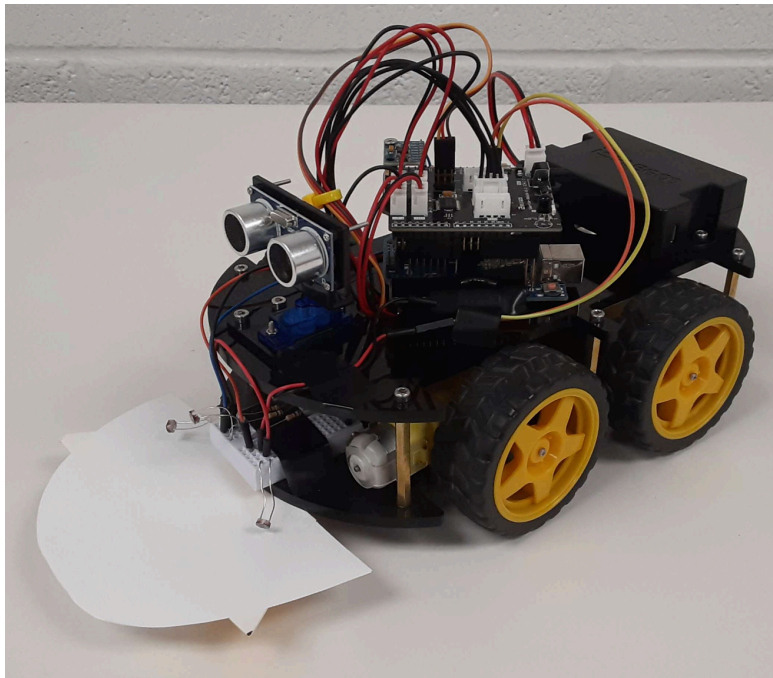


Figure 1: Light Following Robot

Section 2. Team members and contributions

The four contributors to this project are: Kaden Gordon, Sam Morrill, Henry Riker, and Anna Von Niederhausern. Kaden Gordon and Sam Morrill lead efforts in programming. Henry Riker headed efforts in hardware decisions. Anna Von Niederhausern headed efforts in documentation.

Section 3. Project description

A. Mechanical design

The mechanics of the rover are heavily adopted from the base rover, the ELEGOO R3 Smart Robot Car kit V4 for Arduino Projects. A children's toy for smart kids. Its dimensions are 8 x 7 x 6 in. four wheels are driven by small DC motors, housed between the bottom panel and top panel of the rover body. A servo motor controls the mount on the front of the rover on which the ultrasonic sensor sits. The arduino and battery mount on the upper panel, the arduino near the middle, and the battery to the rear.

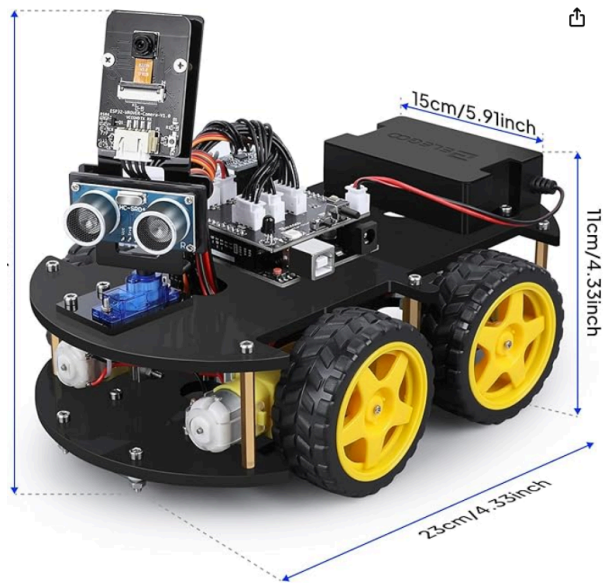


Figure 2: Original Arduino Robot Car

B. Electrical design

The electrical design mostly uses components that are included in the kit. The kit includes an arduino shield that allows for components to be plugged and properly connected to the arduino pins. The shield also contains a 2-channel DC motor driver, IMU chip, IR receiver, and an RGB LED. The schematics for the shield proved helpful for finding the correct pins to interface with the motor driver and ultrasonic sensor (Figure 3).

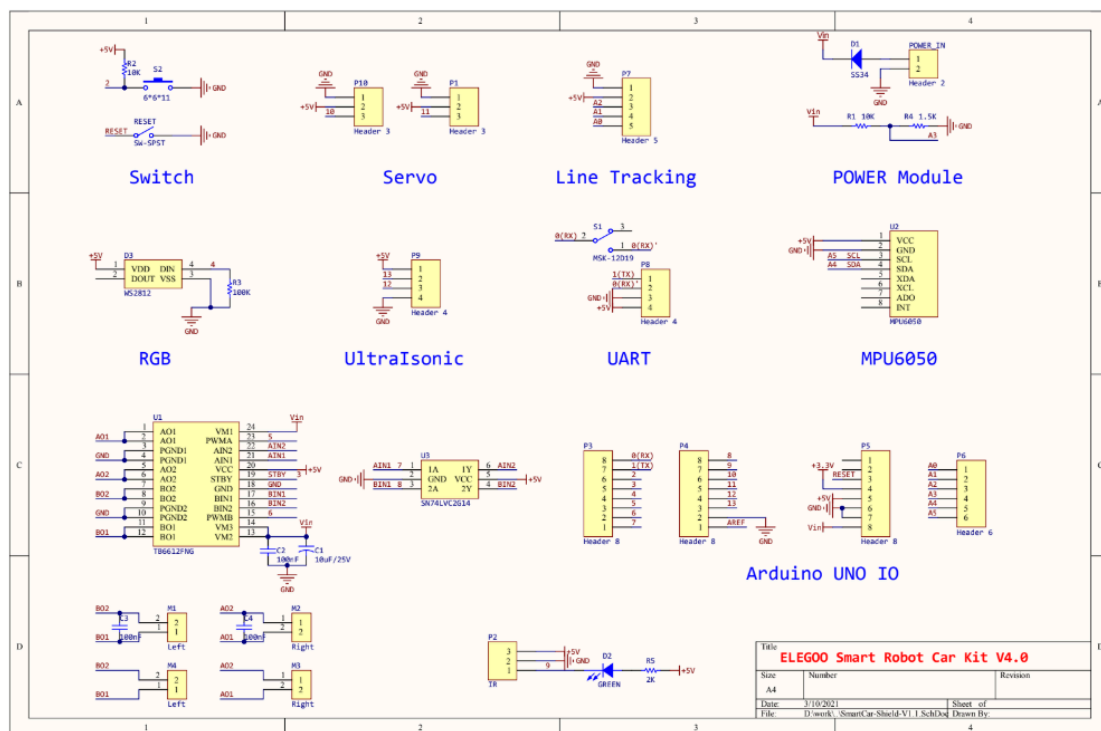


Figure 3: schematic of the rover shield

The motor driver requires 5 pins to control the two channels: two for direction, two for speed (PWM), and one enable signal. The two right motors are driven by channel A, and the left two motors by channel B. This gives the LFR a form of tank-drive, where a difference in speed or direction between the two channels turns the LFR.

The light sensing circuit is composed of two voltage dividers using photoresistors (Figure 4). The output of these circuits are fed into analog input pins on the arduino to determine the direction and magnitude of the turning angle. The light sensing circuit is mounted on the front of the LFR (Figure 5).

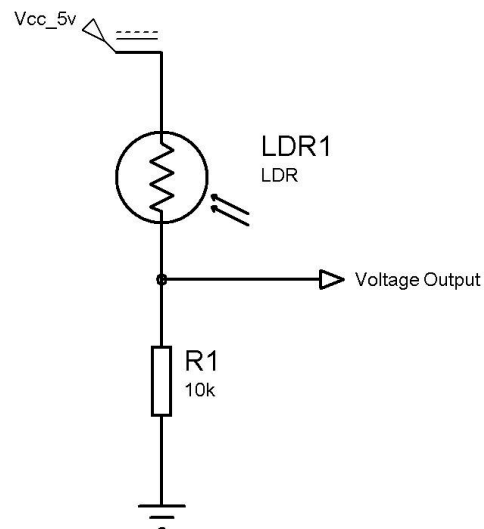


Figure 4: Light sensing circuit diagram

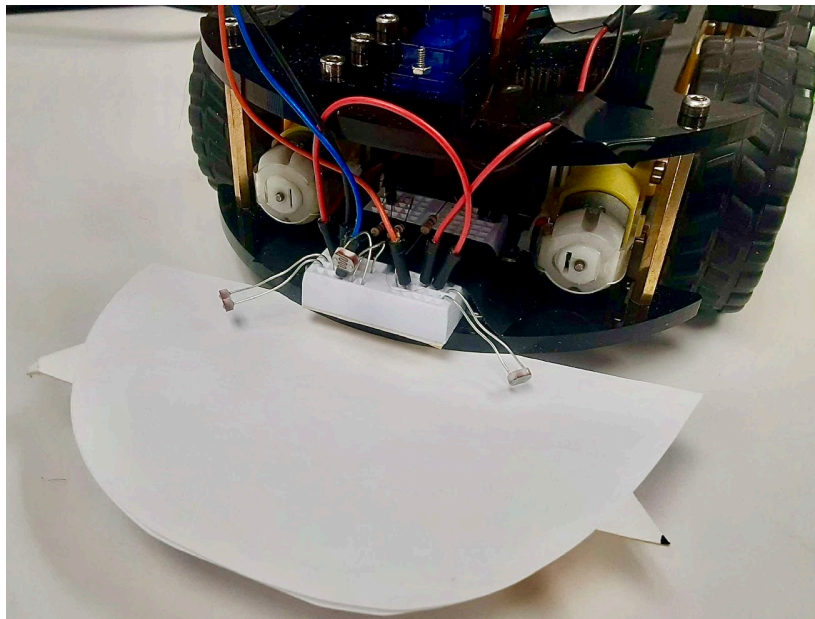


Figure 5: Light sensing circuit mounted on the LFR

C. Hardware selections

The majority of the hardware used in this project came from the rover kit. The resistors, photoresistors, and jumpers for the light sensing circuit were sourced separately. Below is a table of key components, part numbers, and a brief description.

Table 1: Key components

Part	Number	Description	Quantity
Arduino Uno	ARD-A000066	Multi-purpose microcontroller	1
Photoresistors	5539	EBOOT Photoresistor 5 mm	2
DC Motors	Not specified	Small DC motor for RC hobby projects	4
Motor drivers	TB6612FN	Toshiba Bi-CD Silicon Monolithic Driver IC for Dual DC motor	1
Ultrasonic Distance Sensor	HC-SR04	Measurement range: 2cm to 4m	1

D. Closed-loop control system

The two photoresistors receive the levels of light in their respective areas. The levels are adjusted with a gain tuned to the individual photoresistors to give them an equivalent level of functionality. The difference between the two levels of detected light is measured and scaled down by another gain. The signal is then fed through a PID. In our case, the ‘error’ is the difference in detected light levels between the two photoresistors. The proportional component of PID control is simply the magnitude of the error scaled. The Integral part of PID controlling is the cumulative sum of errors over time. The derivative component is the rate of change in the error. The combination of tuning each of these components reduces steady state error while optimizing reaction time and smoothness of the response. The PID gains were tuned to the following values.

P (proportional): 1.23456789

I (integral): 0.5

D (derivative): 0.03

The resulting signal is then passed through a saturation function that ensures the signal does not exceed the bounds of the output pins driving the motors. The signal is then sent to the motors for the wheels of the LFR, and to the servo motor that turns the ultrasonic sensor.

The signal to the servo motor tasked with pointing the ultrasonic sensor is fed through another gain block before it reaches the servo motor. The servo will turn the ultrasonic sensor in the direction of the light to detect potential obstacles while the LFR turns to face the light.

The ultrasonic sensor signal has only two proportional gains applied to it. The first gain is set to 0.5 and its purpose is to convert the signal to distance in centimeters. The second signal amplifies the signal by a factor of 255 before it is fed through a saturation block which confines the signal to the upper threshold of 255, and the lower threshold of zero.

The ultrasonic sensor signal is combined with the PID output to determine the speed of the left and right motors. The ultrasonic sensor determines the base speed of the motors. The PID output determines the difference of speed between the left and right motors.

The resulting behavior is as follows: The photoresistors detect a difference in levels of light. The Ultrasonic sensor is turned to face the direction of the light while the wheel motors start turning the whole LFR toward the light source. The LFR drives like a tank, with the exception of there is no reverse drive. The wheels on each side are driven at a slower or faster rate to turn the LFR to face the proper direction. As the LFR turns, the LFR realigns with the ultrasonic sensor and ends up facing the light. The speed of the wheels is largely determined by the distance to an obstacle. See Figure 6 for the system block diagram, and Figure 7 for the simulink program.

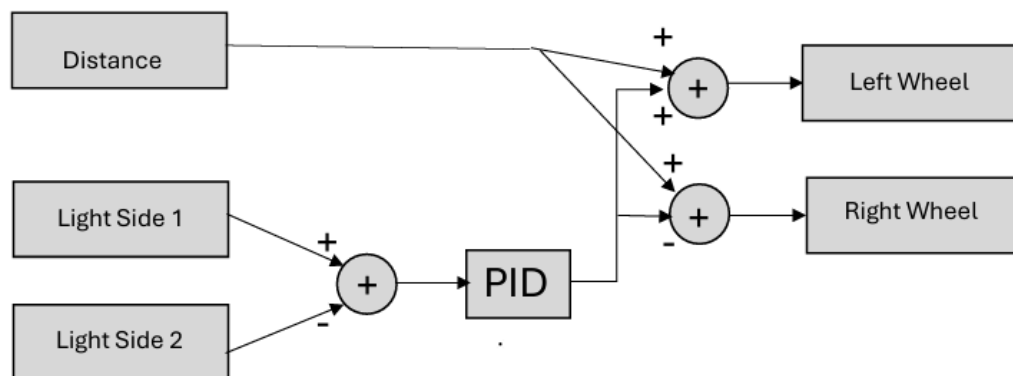


Figure 6: System Block Diagram

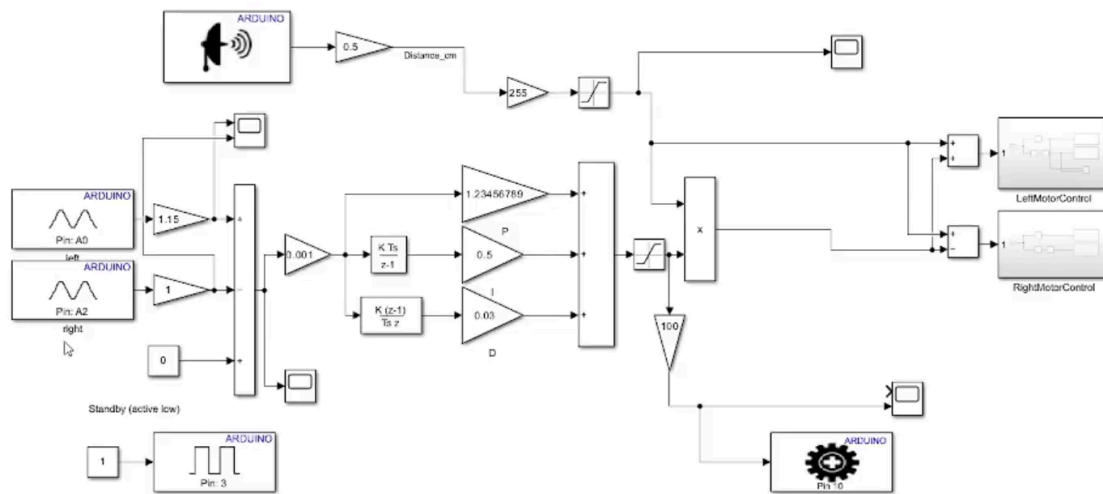


Figure 6: Simulink Program

Section 4. Results

The light following capability function works properly, and the LFR can be driven with a flashlight. The adjustment and angle of the photoresistors does affect the tuning on the PID. The type of flooring and room lighting also affects the light following abilities. For more consistent results, a white board was attached to the front of the LFR to reflect more light into the photoresistors.

The LFR successfully keeps itself from crashing into obstacles. The downside is, once the LFR gets too close to an obstacle, it cannot escape it, and external help is required to free the LFR and give it enough space to follow light again. Due to time constraints, the light following function and PID tuning tasks were prioritized. The issue with obstacle entrapment was left as an improvement for a future version of the LFR.

As for PID tuning, the target behaviour was somewhat arbitrary. However, the final tuning was suited for a rover in open terrain: easy to walk along with the LFR, no jittering or oscillation, smooth turns, and stops before colliding with obstacles.

Section 5. Conclusions

PID controlling is overkill for this particular application. Given more time and materials and funding a more conducive housing could be made to keep the photoresistors from getting bumped, moved, or rearranged in general. Additionally, the main problem with the current design is the LFR gets stuck if it gets too close to an obstacle. Currently the LFR slows down enough that it can be redirected before it halts, but if it does halt, then manual interference is required to free the LFR. This could be fixed by multiple methods. First, a reverse drive could be added for close proximity front facing obstructions. Second, an additional set of photoresistors can be added to the rear side of the LFR, and tied to a reverse drive, to allow the user to use light to direct the LFR to drive backwards, and then resume chasing the light as normal.

Section 6. References

Link to ELEGOO R3 Smart Robot Car kit V4 for Arduino Projects:

https://www.amazon.com/ELEGOO-Tracking-Ultrasonic-Intelligent-Educational/dp/B07KPZ8RSZ/ref=sr_1_1?sr=8-1

Motor driver datasheet: <https://cdn.sparkfun.com/datasheets/Robotics/TB6612FNG.pdf>

Link to photoresistors: [link](#)