PRINCIPLES AND APPLICATION OF MICROCONTROLLERS
Arduino Lab4: Line Following Robot with Obstacle Avoidance

Introduction

In this lab, you are required to design and build a line following robot. The robot needs to have a function that detect and bypass obstacles on its path automatically. The robot returns to its path of the black line after bypassing the obstacles (see Fig. 1). After completing this lab you should be able to:

- Design obstacle avoidance logic
- Understand the working principles of IR sensors
- Perform analog signal acquisition and analog to digital conversion

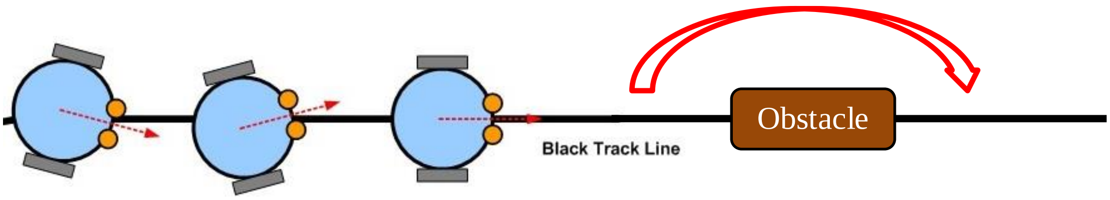


Figure 1: Circuit chart of the line following robot

Parts List

- A wheel robot set
- An Arduino Uno MCU
- A breadboard
- A DMS sensor
- An H-bridge board
- Batteries
- IR sensors

Infrared Sensor Module

An infrared (IR) sensor is an electronic device that emits and detects IR radiation in order to sense some aspect of its surroundings. An IR sensor is composed of an emitter and a receiver (Fig. 2). The basic concept of IR obstacle detection is to transmit an IR signal from the emitter in a direction. If there is an object in the direction, the IR signal bounces back and is received by the IR receiver.

IR sensors are color sensitive. Black color patches block all the light (Fig. 3). The IR signal from the emitter does not bounce back to the receiver if the obstacle surface is in black. In this lab, we use black tape to create a line. The signal of the IR sensors on the line is different than the signal of the IR sensors off the line. This makes it possible to create a line following robot.

Figure 2: A pair of IR emitter and receiver

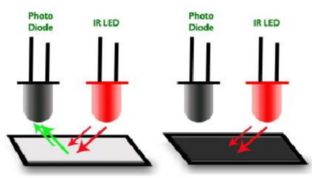
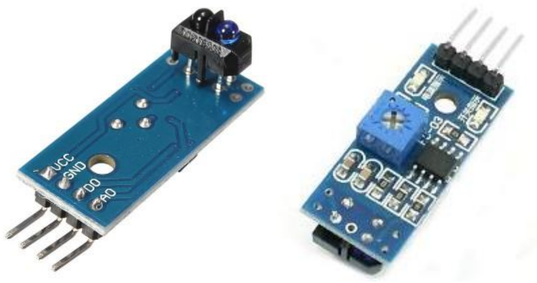


Figure 3: Color sensitivity of IR sensors

The IR sensor module we will use is an integrated IR component. It has an analog output A0 and a digital output D0 (Fig. 4a). The analog output pin A0 is the output of the IR receiver and can be used to evaluate the distance between the IR sensor module and an obstacle using the ADC of a MCU. The pin D0 outputs HIGH when the object distance is greater than a threshold; otherwise, the pin D0 outputs LOW. The threshold can be adjusted by rotating the blue potentiometer in the back of the module (Fig. 4).



(a) (b)

Figure 4: IR sensor module

DMS Sensor

DMS sensors (Sharp IR rangers) are specially designed IR sensors. These sensors are not affected by color as much as regular IR sensors. Figure 5 shows a Sharp GP2Y0A21YK DMS sensor. The DMS sensor uses triangulation and a small linear CCD array to compute the distance and presence of objects in the field of view. Figure 6 illustrates the principle of the triangulation. Similar to regular IR sensors, a pulse of IR light is emitted by the DMS sensor. If the light reflects off an object, it returns to the detector and creates a triangle between the emitter and the detector. The incident angle of the reflected light varies based on the distance to the object. The receiver portion of the DMS sensor is a precision lens that transmits reflected light onto various portions of the enclosed linear CCD array based on the incident angle of the reflected light. The CCD array can then determine the incident angle, and thus calculate the distance to the object. This method of ranging is very immune to interference from ambient light and offers indifference to the color of the object being detected. Figure 7 shows the output distance characteristics of the Sharp GP2Y0A21YK sensor. The distance measuring range is approximately 10 to 80 cm. For details of the sensor, please refer to its datasheet.

Figure 5: Sharp DMS sensor

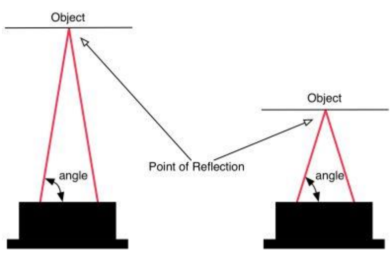


Figure 6: Working principles of DMS sensors

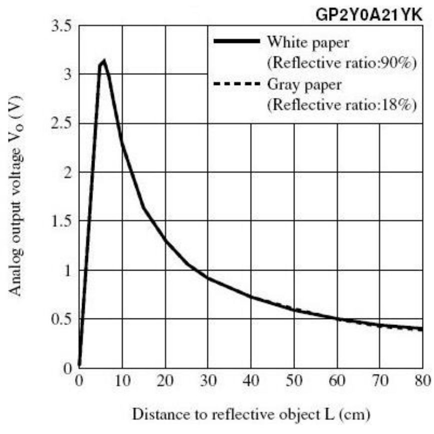


Figure 7: Analog output versus distance to object

Procedure

Assemble your circuit by following the diagram as shown in Fig. 8. We will use pins 5, 6, 10, and 11 as the outputs to control the 2 DC motors. Pins A0 through A3 are used as the inputs from the IR sensors and the DMS sensor. Note that all the GNDs in a circuit should be connected together.

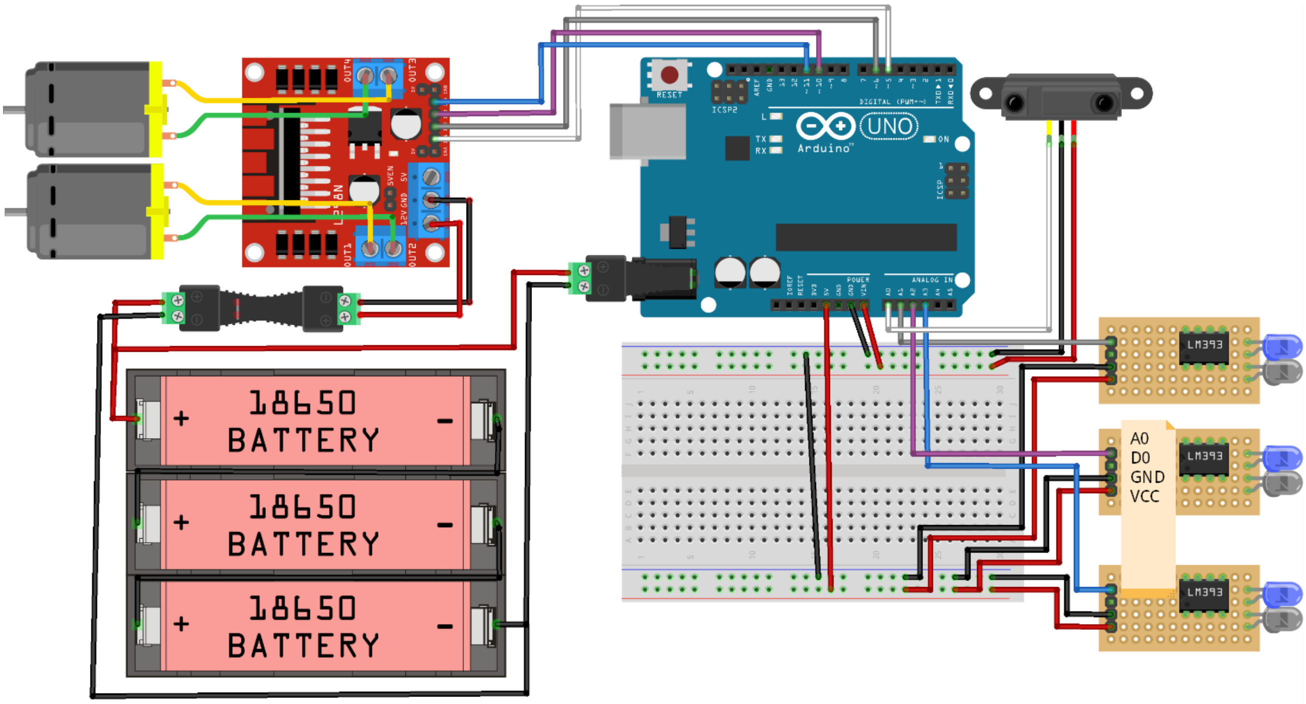


Figure 8: Circuit chart of the line following robot

The line following robot can be programmed using reactive control strategies. Reactive control is a technique for tightly coupling sensory inputs and effector outputs, allowing the robot to respond very quickly to changing environments. For example, when the right IR sensor of the robot detect black line, the control action to the robot should be turn right. Remember to calibrate your IR sensors (i.e., getting the readings of the black and white areas) in the initialization. Figure 9 shows the flowchart of reactive control planning.

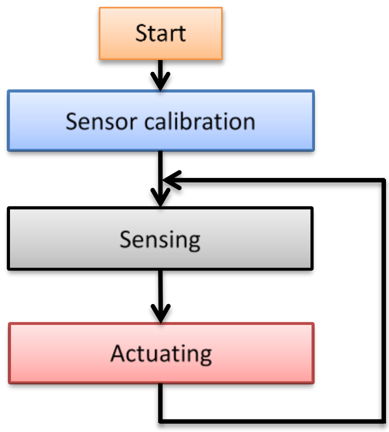


Figure 9: Flowchart of reactive control

Deliverables

<u>Basic + advanced points (100%):</u>

Demo your line following robot to the TAs, or record it in a video. Upload the followings to ceiba: 1) your Arduino scratch, 2) a photo of your physical circuit, and 3) contributions from each teammate to the lab. The contributions must include the information of the tasks each teammate has done and the contributions in percentage. The total percentage should be 100%. All the teammates have to agree with the contributions before they are uploaded.

Bonus

You will obtain a 10% bonus if you program your robot to do a S-shape line tracking.