The Chinese University of Hong Kong
Department of Computer Science and Engineering
CENG2030 Fundamentals of Embedded System Design

Lab 8: Sensor and Actuator

Submission Instructions:
■ You are required to submit **demo videos**, **answer sheet**, and **Arduino codes** to Blackboard.
■ Create each Arduino project with a project name based on the lab and question numbers, e.g. "**ceng2030_lab8_q1**".
■ Zip all the files to one single zip/rar file named with your student ID number, e.g. "**1155123456.zip**".
■ **Upload the zip/rar file to Blackboard by 18:00pm on the same day**, **10 marks** will be deducted **per hour**

For each question below, you are required to record a short mp4 **video** to demonstrate your works. In the video, the following elements are required:
A. Show your full name and SID on a paper next to your circuit   [5 marks]
B. Voice descriptions in English/Cantonese/Mandarin on what you are doing   [5 marks]
C. Demonstrate your works by presenting all possible cases clearly   [20 marks]

List of Components and Equipment:
■   Arduino: 1x Arduino UNO Board with USB cable
■   Breadboard: 1x Breadboard and Wires
■   Resistors: 1x 270Ω
■   LED: 1x LED
■   Sensor: 1x IR sensor
■   Actuator: 1x Servo Motor

1. **IR Sensor**

Let's use the IR sensor to build an obstacle detector. If there is any obstacle in front of the IR sensor, the red LED will light up.
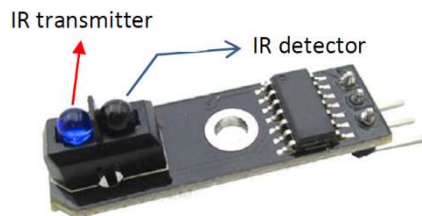
On the IR sensor module, there is one IR transmitter and one IR detector. On the other end, there are 3 pins, namely VCC, GND, and OUT. The pin assignments/locations of the actual module may be different from the picture above. So, please verify them carefully.

Build the following circuit to test the IR sensor with the Arduino UNO board. For more information on the Arduino UNO Board, please visit https://store.arduino.cc/usa/arduino-uno-rev3
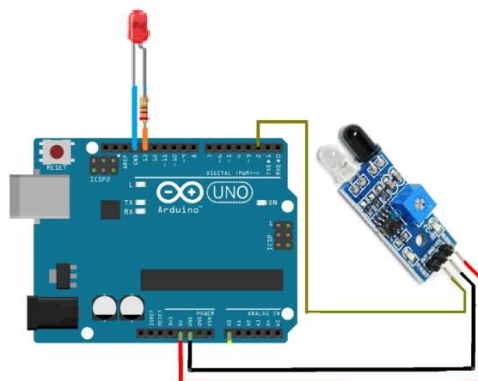
a. Hardware Connections
   i. Connect the 270Ω resistor to digital output pin 13 of the Arduino UNO board.
   ii. Connect the anode (i.e. the positive terminal, and normally the longer leg) of the red LEDs to the other end of the resistor
   iii. Connect the cathode (i.e. the negative terminal, and normally the shorter leg) of the LEDs to the GND pin of the Arduino UNO board
   iv. Connect the VCC pin of the IR sensor to the 5V pin of the Arduino UNO board
   v. Connect the GND pin of the IR sensor to the GND pin of the Arduino UNO board
   vi. Connect the OUT pin of the IR sensor to the digital output pin 2 of the Arduino UNO board
   vii. Connect the Arduino UNO Board to your computer by using the USB cable
   viii. Answer the questions on the answer sheet

b. Software Programming
   i. On the desktop of your computer, double click the following Arduino icon to execute the Arduino IDE
   ii. Create a new project by:
      1. Click File > New, a new window will pop up
      2. Copy the codes below

```
int red = 13; // this number indicates the pin number of the Arduino board
int ir  = 2;

void setup() {
        // set the input & output pins here
}

void loop() {
        // read the output digital signal from the IR sensor
        // if an obstacle is detected, turn the red LED on
        // if there is no obstacle, turn the red LED off
}
```

      3. Paste the codes and replace everything in the new pop up window
      4. Modify the codes to build the obstacle detector as remarked in the codes.
      5. Click Sketch > Verify/Compile, change the name of the folder/program and Save
      6. If the codes are compiled correctly without error, "Done compiling." will be shown
   iii. Check the following Arduino settings:
      1. Click and choose Tools > Boards: "Arduino/Genuino Uno"
      2. Click and choose Tools > Port > COM??? (other than COM1 normally)
   iv. Compile and upload the program to the Arduino
      1. Click Sketch > Upload
      2. If there is no error, "Done uploading." will be shown
   v. Answer the questions on the answer sheet

2. **Servo Motor**

Keeping the circuit of Question 1 connected. Add the servo motor as another output device. There are 3 pins on the servo motor, they are VCC (Red), GND (Brown), PWM (Orange).
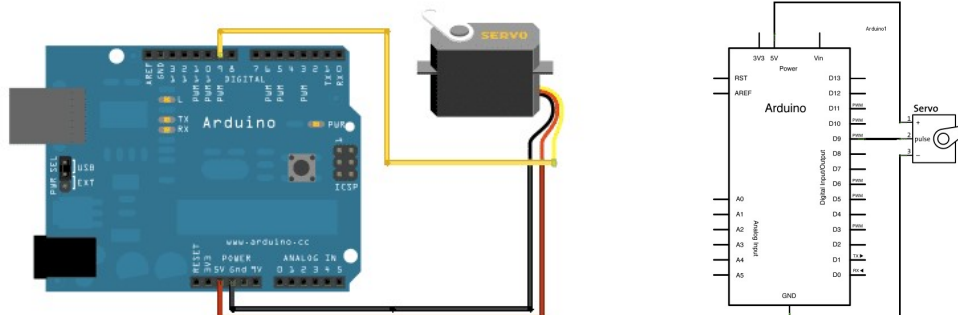
a. Hardware Connections
    i.   Connect the VCC and GND pin of the servo motor to the VCC and GND pins of the Arduino UNO board respectively
    ii. Connect the PWM pin of the servo motor to pin 9 of the Arduino UNO board
    iii. Attach a part/label on the rotational axis of the servo motor, so that the rotation can be visualized easily
    iv. Connect the Arduino UNO Board to your computer by using the USB cable
    v.   Answer the questions on the answer sheet

b. Software Programming
    i.   On the desktop of your computer, double click the following Arduino icon to execute the Arduino IDE
    ii. Create a new project by:
        1. Click File > New, a new window will pop up
        2. Don't just copy this time! Understand the following codes which is used to setup and control the servo motor. Please note that a positional rotation servo motor used in this lab can only rotate between 0 to 180 degrees (NOT 360 degrees).

```
#include <Servo.h>

Servo myservo;  // create servo object to control a servo
int pos = 0;    // variable to store the servo position

void setup() {
  myservo.attach(9);  // attaches the servo on pin 9 to the servo object
}

void loop() {
  for (pos = 0; pos <= 180; pos += 1) { // goes from 0 degrees to 180 degrees
                                        // in steps of 1 degree
    myservo.write(pos);  // tell servo to go to position in variable 'pos'
    delay(15);           // waits 15ms for the servo to reach the position
  }
  for (pos = 180; pos >= 0; pos -= 1) { // goes from 180 degrees to 0 degrees
    myservo.write(pos);  // tell servo to go to position in variable 'pos'
    delay(15);           // waits 15ms for the servo to reach the position
  }
}
```

        3. Modify the codes in Question 1 by inserting **some of the codes** below, in order to do the following tasks:
            ■ Keep the functions in Question 1
            ■ If an obstacle is detected for the first time, rotate the servo motor to the 0 degree position
            ■ If an obstacle is detected again, rotate the servo motor to the 180 degree position, and so on…
        4. Click Sketch > Verify/Compile, change the name of the folder/program and Save
        5. If the codes are compiled correctly without error, "Done compiling." will be shown

    iii. Check the following Arduino settings:
        1. Click and choose Tools > Boards: "Arduino/Genuino Uno"
        2. Click and choose Tools > Port > COM??? (other than COM1 normally)

    iv. Compile and upload the program to the Arduino
        1. Click Sketch > Upload
        2. If there is no error, "Done uploading." will be shown

    v.   Answer the questions on the answer sheet

Lab 8: Sensor and Actuator

Answer Sheet

Full Name:_____   SID:_____

Demo Video   **[30%]**

1. **IR Sensor**   **[40%]**

    a.   Hardware Connections

          What type of output signal is provided from OUT pin of the IR sensor, digital or analog?

          _____

          IR frequencies range from about 300 GHz up to about 400 THz. Is the frequency of the visible Red light below or above this frequency range?

          _____

    b.   Software Programming

          What is the voltage of OUT pin of the IR sensor if an obstacle is detected?

          _____

          Based on the settings of this lab, can we measure the distance of the obstacle to control the brightness of the LED? Why?

          _____

2. **Servo Motor**   **[30%]**

    a.   Hardware Connections

          What PWM stands for?

          _____

          Instead of connecting the PWM pin of the servo motor to pin 9 of the Arduino UNO board. Can we connect it to pin 3 of the Arduino UNO board? Why?

          _____

    b.   Software Programming

          How can we rotate the servo motor faster?

          _____

THE END