EECE.4520/5520 Microprocessor II and Embedded System Design

Lab 3: Use Sensors to Control Motors

last update: 10/30/2023

General Information

Lab Mode: Remote. You need to work on the lab remotely on your own computer with your own lab kit.
Lab Due Date: Posted in Blackboard. You need to submit all the required deliverables on or before the due date.
Lab Report Submission: Submit via Blackboard. No email submissions are accepted
Lab Contents: Additional requirements applied for EECE.5520. EECE.5520 (graduate level section) students need to complete additional lab requirements.

Lab Description

This lab is to design a controller to obtain sensor data which are used to control motors. There are a plethora of sensors and the lab kit includes a number of them. For EECE.4520 students, you will use a microphone sensor (sound module), whereas students in EECE.5520 will use an ultrasonic distance sensor. The lab details are given in the follow subsections.

1. EECE.4520

This lab is to design a controller to control a fan driven by a DC motor. Your design needs to display the clock and the fan's rotation direction and speed. You must use a timer interrupt. Your system will use sound sensor to detect music notes and control the speed of the motor. The following are the features your system should have:

(1) use the Arduino to control a DC motor that turns a fan. The fan can run at different speeds and in either direction (clockwise or counterclockwise)
(2) set up a Real Time Clock (RTC) and retrieve time information from the RTC. You only need to retrieve the time once when you power on your system.
(3) display the real-time clock **and** the fan's rotation direction ("C" for clockwise, or "CC" or counterclockwise) and speed ("Full", "3/4", "1/2", or "0") on a 2-row LCD display
(4) update the information every second so that the display shows the up-to-date time
(5) use the sound sensor module to sample pre-recorded tones and convert the sound to digital values
(6) use FFT library to process the audio samples and detect peak frequencies
(7) compare the peak frequencies detected against know patterns. The pattern to match is music notes "C4" and "A4" (with frequency of 262Hz, 440Hz, respectively). If the note is "C4", increase the fan speed by one step (e.g. 0 to ½, or ½ to ¾). If the note is "A4", decrease the fan speed by one step. To match with the frequencies, an error of 2% is allowed. For example, you can recognize the note as C4 if the peak frequency is in the range of between 257Hz and 267Hz.

2. EECE.5520

This lab is to design a robot car that can drive itself surrounding a trash can (or a one-gallon milk bottle :-). The robot car is built from a robot kit that you can pick up from the professor or

TA. You will need to follow the assembly guide to assemble the two-wheel car (reference [4]). Your system should support the following features:

(1) Use the Arduino to control the two DC motors to drive the car moving forward, backward, turn left, or turn right.
(2) Use the ultrasonic distance sensor to measure the distance between the car and a nearby object such as a trash can.
(3) Implement a control algorithm to drive the robot car such that the car cycles around a trash can (or other object placed on the floor) but never touches it. You can refer to the demo video (reference [5]).
(4) use the sound sensor module to sample pre-recorded tones and convert the sound to digital values
(5) use FFT library to process the audio samples and detect peak frequency
(6) compare the peak frequencies detected against know patterns. The pattern to match is music notes “C4” and “A4” (with frequency of 262Hz, 440Hz, respectively). If the note is “C4”, stop the robot car. If the note is “A4”, allow the robot car to continue its movement. To match with the frequencies, an error of 2% is allowed. For example, you can recognize the note as C4 if the peak frequency is in the range of between 257Hz and 267Hz.

Lab Materials:

Required Parts:

Part name	Quantity	Notes
Arduino board	1	
DC Motor	1	
Power supply module	1	for DC motor (EECE.4520)
L293D	1	
LCD	1	EECE.4520 only
DS1307 RTC	1	EECE.4520 only
Button	1	
Sound module	1	
Robot kit (includes top/bottom plates, battery, charger, tt motors, wheelsets, etc)	1	EECE.5520 only. Pick up from the professor
assorted jumper wires	as needed	

References:

1. Arduino IDE: https://www.arduino.cc/en/main/software
2. The resource files (sample code and tutorials) from Elegoo: https://www.elegoo.com/download/
3. For EECE.5520 students, you need to install “arduinoFFT” library through the IDE’s library manager tool.

4. For EECE.5520 students, you need to refer to the robot car assembly guide to build the two-wheel robot car: https://github.com/ACANETS/eece-4520-5520-labs/blob/2039441de8a069a14cadbb58f175f142d48f87c0/lab3/assembly%20guide.md
5. Hugging bot demo video: https://youtu.be/7CNUAesYvLU

Lab Instructions

Step 1:
You can first check the resource files under the following folders

- 2.23 DC Motors
- 2.21 LCD Display
- 2.18 Real Time Clock Module
- 2.19 Sound Sensor Module (for EECE.4520 students)
- 2.9 Ultrasonic distance sensor

These folders contain useful instructions on hardware wiring and sample code to drive these components. You are encouraged to try these examples as you can then build your lab 3 upon these examples.

Read the tutorial on Timer Interrupt

$$ HINT $$

Please plan the locations of components on the breadboard wisely. You should start with putting the breadboard power supply to the edge of the breadboard (refer page 3 in Lesson 2.23) and using the 9V battery, AC110/DC9V or USB-A to supply the power to the Elegoo power board. This can help leave enough room for arranging other components on the breadboard.

!! CAUTION !!

You should **_NEVER_** connect a motor directly to the Arduino, because when you switch a motor off you get an electrical feedback. Even with a small motor, this will damage your Arduino, and with a large motor, you may see an “interesting” flame and sparks effect. ☹

Step 2:
Wire up the DC motor circuit by following the instructions in lesson 2.23. Have your teammates doublecheck the circuit before you power up the system. Modify the example code to run the DC motor a specified speed.

Step 3:
Wire up RTC clock module to the I^2C pins of Arduino. Modify the example code to update the current time and retrieve the new time. Check if the clock is at the beginning of a minute. If so, turn the fan on and let it run for 30 seconds.

Step 4:
Wire up the LCD module. Display the current time and fan rotation direction and speed. The display should be always on, even when the fan is not rotating.

Step 5:
Set up the timer interrupt. Use the Interrupt Service Routine (ISR) to update the information (clock, rpm, direction) every second.

Step 6: Wire up Sound Sensor module circuit as illustrated in lesson 2.19. Test the sample code to process the recording.

Step 7: Install and test the sample code of ArduinoFFT library. The music tones for testing are released by the instructor.

Step 8:
Test and debug your design.

Step 9: (optional)
Record demo video and post it on Youtube.

<for EECE5520 students>

Step 8: follow the assembly guide to assemble the two-wheel robot car.

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Please refer to lab demonstration and report guidelines for demonstration and report writing.