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EE445L
TTH 12:30-2PM Lab

Lab 11 Report

Preface

One of the H-bridges was producing 3.3v on an input pin for some reason and could not be replaced in time for the expo. Project overall was demonstrated at the expo but had only one motor working, so demonstrations were limited to just having it turn using the remote control one way or another. Completed entire project solo and used three proto boards to wire ICs and sensors to Arduino and TM4C since PCB was not sent off for production due to T-V and T-P errors.

Lab 11 Goals

Goals	• Build and test an embedded system.
Review	• none
Starter files	• none

Background

You will complete the embedded system you began in Lab 7. This lab includes hardware construction, software debugging and system evaluation. There will be a “Science Fair”-like public demonstration for Lab 11. I will present special awards to the team of two with the best design. The preliminary round will be judged by your TA during your lab session, and the final round will be judged by other students and observers.

Requirements Document

1. Overview

1.1. Objectives: The purpose of this project is to design an embedded system and study the topics of power, ADC, DAC, interrupts, UART, displays, and programming for the embedded system. Understanding PCB design and how the components interact with each other in the embedded system are integral to the completion of the lab.

1.2. Roles and Responsibilities: The clients are the TA and the Professor. I (the student) will be designing the PCB and programming for this lab.

1.3. Interactions with Existing Systems: There will be GPIO analog sensor readings, digital outputs, and power interactions between the PCB and the LaunchPad. Data transfer will occur between the LaunchPad and a wearable device with a NodeMCU using an HC-08 BLE module with UART.

2. Function Description

2.1. Functionality: The system will consist of a motorized vehicle that can operate autonomously to follow a person or be controlled directly from a wearable device using Bluetooth communication. IR receivers will allow the robot to track a beacon worn by the individual and an accelerometer or flex resistors embedded in the wearable device will enable remote control over the system. LCD displays will relay information to the user about the mode the robot is in, IR sensor data, motors/gears in use, and the inputs it is receiving from the controller.

2.4. Performance: Once the final design is assembled, power measurements will be determined based on the current draw of the system using either a power supply or a voltmeter. For initial current approximations, datasheet information will be used and the current draw of each individual component under load will be measured. Performance will be based on how accurately the robot can follow the user and its responsiveness to commands sent via the wearable system.

2.5. Usability:

Human interfaces will include the following:

- ST7735R LCD on robot will output visualizations of the sensor data such as IR distance readings, accelerometer data, motor power output. LaunchPad will connect to ST7735R display
- SSD1306 OLED 128x32 pixels on wearable will show basic information (robot mode, commands to send to robot, ect.). This will be connected using SDA and SCL lines to the NodeMCU
- Momentary buttons on both robot and wearable to access different software functions, display information and levels of control

Other interfaces between main components will include the following:

- UART between the HC-08 BLE module and the LaunchPad (115200 baud rate)
- Bluetooth between HC-08 BLE module and Arduino Node MCU on wearable device
- L293NE H-bridge for drive motor control using LaunchPad GPIO pins, L293NE allows for forward, reverse, coasting, and braking
- 711 DC motor for forward and reverse drive controlled through L293NE
- HiTEC HS-422 servo controlled by LaunchPad PWM GPIO pins to steer wheels
- IR detector and LaunchPad GPIO pins for analog readings
- Raw data sent between 6-axis gyro/accelerator to the NodeMCU, which is in turn sent in the raw form to the LaunchPad for processing (do as much on the LaunchPad as possible since it is used for the class)

3. Lab 11 Completion and Deliverables

Preparation (do this before your lab period)

Part a) Write the main high-level application that implements the final objective of the embedded system. If you want change what your system does, please get approval from your TA.
Part b) Add more detail to the requirements document you began in Lab 7. In particular, give more detail about how the system will be evaluated. Increase the length from one page to two pages.
Part c) Gather all the parts needed to build the system. Update your bill of materials (BOM)
Part d) Solder all parts needed to connect the JTAG and download code to the board, described below as steps 1–6. You should build the board in this order (steps 1-6 are prep, steps 7-10 are procedure). You should be ready to begin step 7 at the start of your first lab period. We recommend you apply power to your PCB only after you have shown completed steps 1–6 to your TA.

Deliverables (exact components of the lab report)

A) Objectives

2-page requirements document

B) Hardware Design

Detailed circuit diagram of the system (from Lab 7)

C) Software Design (no software printout in the report)

Briefly explain how your software works (1/2 page maximum)

D) Measurement Data

Include data as appropriate for your system. Explain how the data was collected.

E) Analysis and Discussion (none). The YouTube video is required

Checkout (show this to the TA)

You should demonstrate the operation of the embedded system.

A software and report files must be uploaded as instructed by your TA

Measurements

Most testing and measurements were done through the ST7735R LCD screen soldered to the robot's protoboard. The raw values that were sent to the TM4C through the BLE module UART were printed out on the screen as well as the UART strings and conversions. This was the key step in ensuring the right commands were being sent and that the data was being processed and acted upon as intended. The software functions were also debugged using the Keil device debugger to see the values stored in variables, how the data was being manipulated, and if the UART FiFo was working correctly.

Measurements taken for Lab 11 include single motor current powered using 9V from a battery through an L293NE H-bridge IC. The current for a single motor under the weight of the robot using a gearbox was measured to be 1.17 Amps using a multimeter. Analog IR receiver values were calculated by holding an IR diode and moving it across the face of the IR receiver from edge to center. The ADC value recorded for the IR light incident on the receiver at an angle that required the robot to turn/course correct to one side for example was found to be around 110 or less. If the ADC value exceeded 30 then the robot needed to course correct to the other side. Anything in between those values meant that between the two IR receivers, the IR source was dead center between the two (not too close to one side or the other).

Recap from Lab 7 and 8 (old but useful information for Lab11):

Total cost to produce the system (cost of all components minus ones provided by class/lab) is approximately $59.06 at current market prices. I currently own all of the required parts, so there is no wait time or shipping costs associated with starting the manufacturing process of the embedded system. See Lab 7 BOM for complete details.

For the vehicle system, the peak current draw based on individual component values under load is approximately:

- 80mA for the LaunchPad
- 35mA for the HC-08
- 55mA for the ST7735R
- 250mA-300mA for the HS-422 servo (high load)
- 1.6A for the 711 brushless DC motor at max
- 15mA x 4 SHARP QH3031 IR Receivers
- 47mA for worst case logic and output levels for the L293NE H-bridge

Thus, the total approximate current draw for the vehicle system alone is 2.177 A at full load. To last close to one hour under full load at the class Expo, a 5000mAh battery would be required.

The peak current values for components used in the wearable device is approximately:

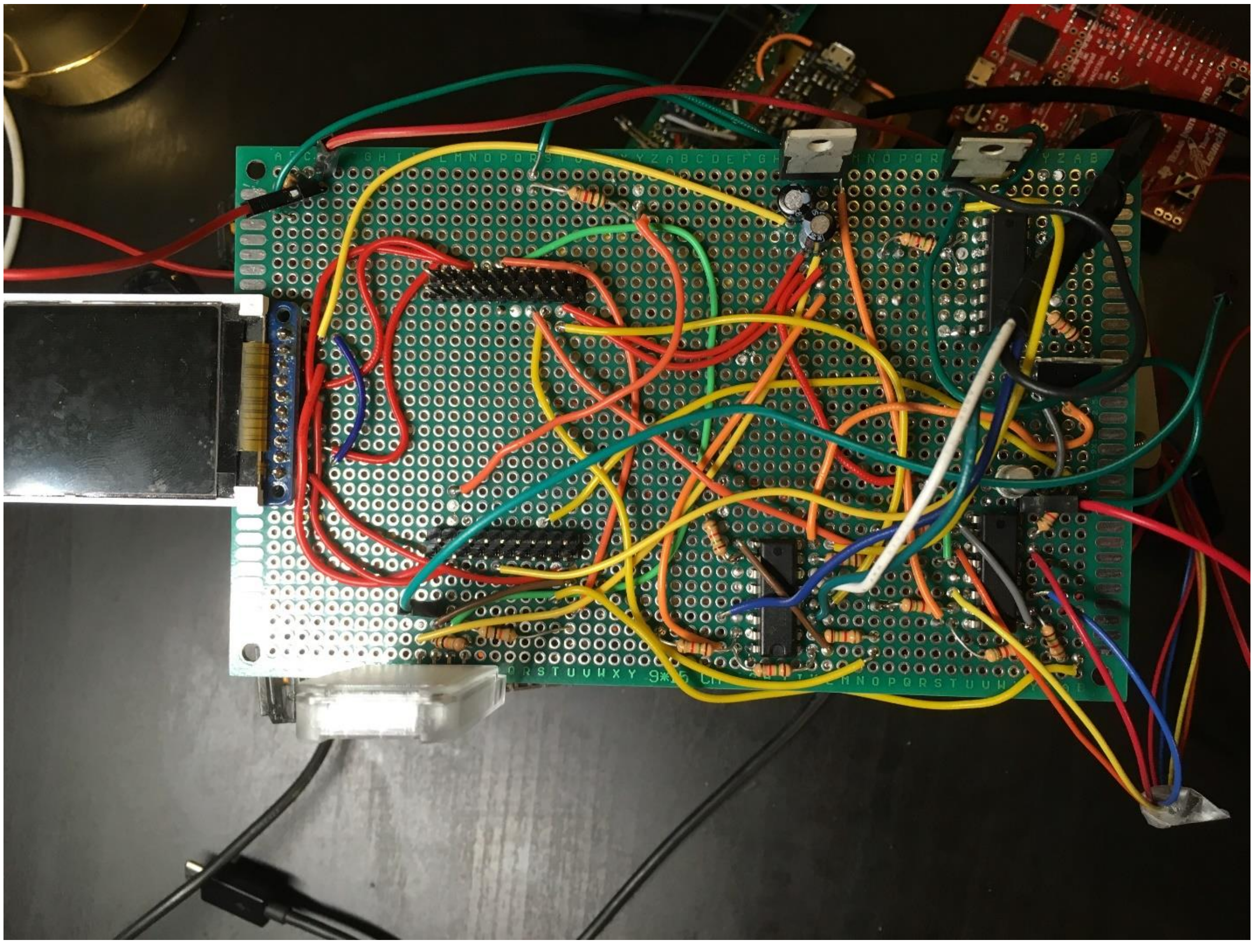
- 67mA for the Arduino MetroMini with HM-10 BLE module
- 20mA for the SSD1306 OLED
- 18mA x 2 IR diodes as a beacon for robot to follow
- 15mA for the accelerometer

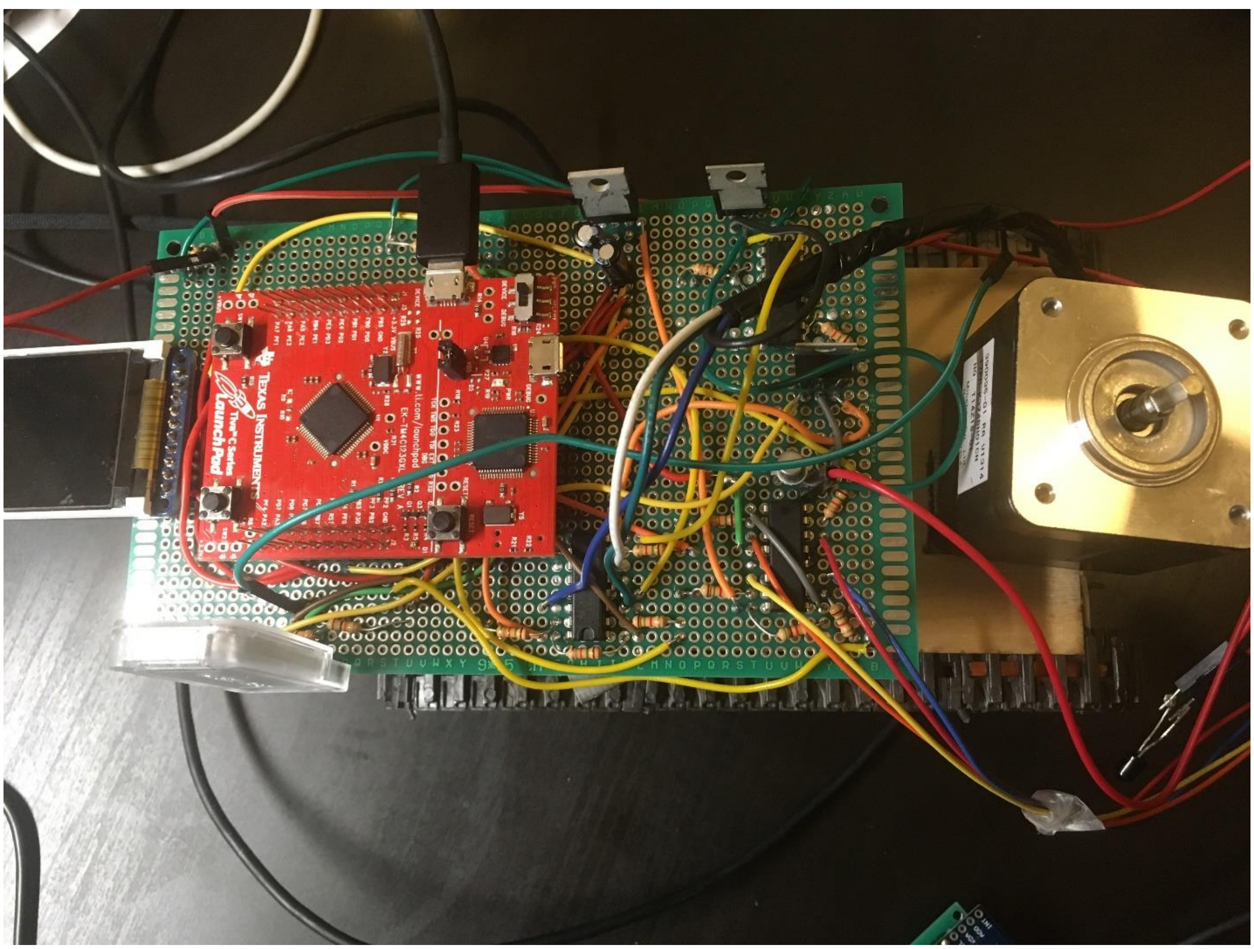
The total approximate current draw is 138mA for the wearable system. To last the duration of the class Expo, a 250mAh battery would suffice.

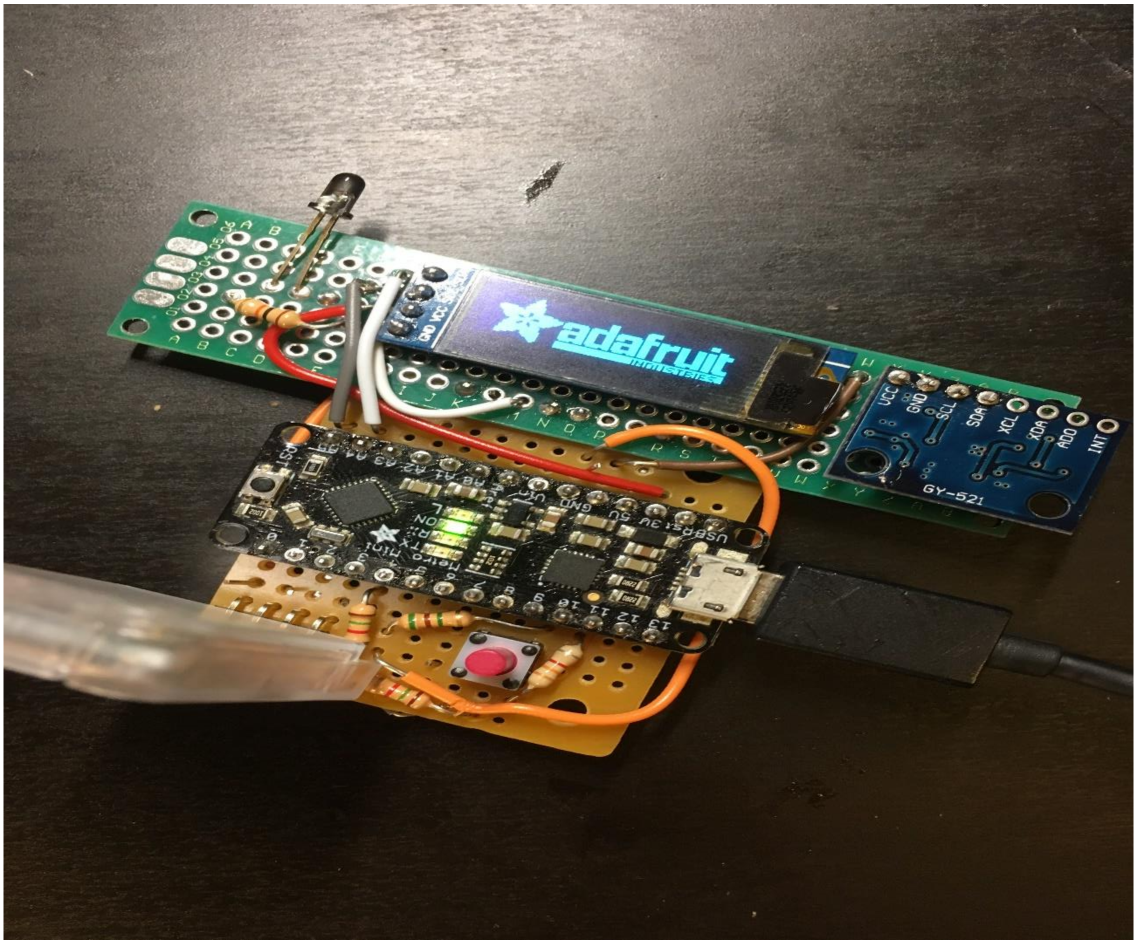
Deliverables

Software files, BOM, and schematics have been submitted to Canvas. A link has been sent to the TAs and Professor to a short video highlighting the project design, components, and functionality.

Below are some pictures of the final design:




Texas Instruments
LaunchPad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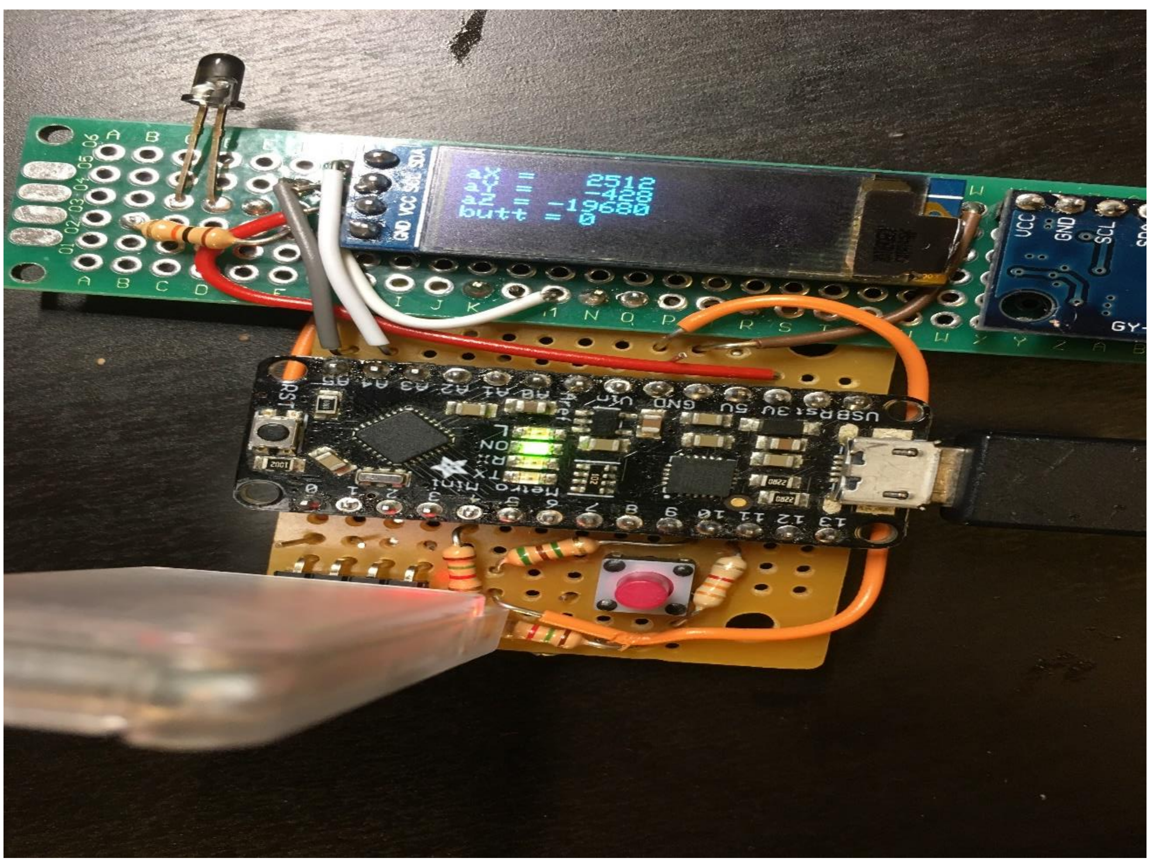
GY-521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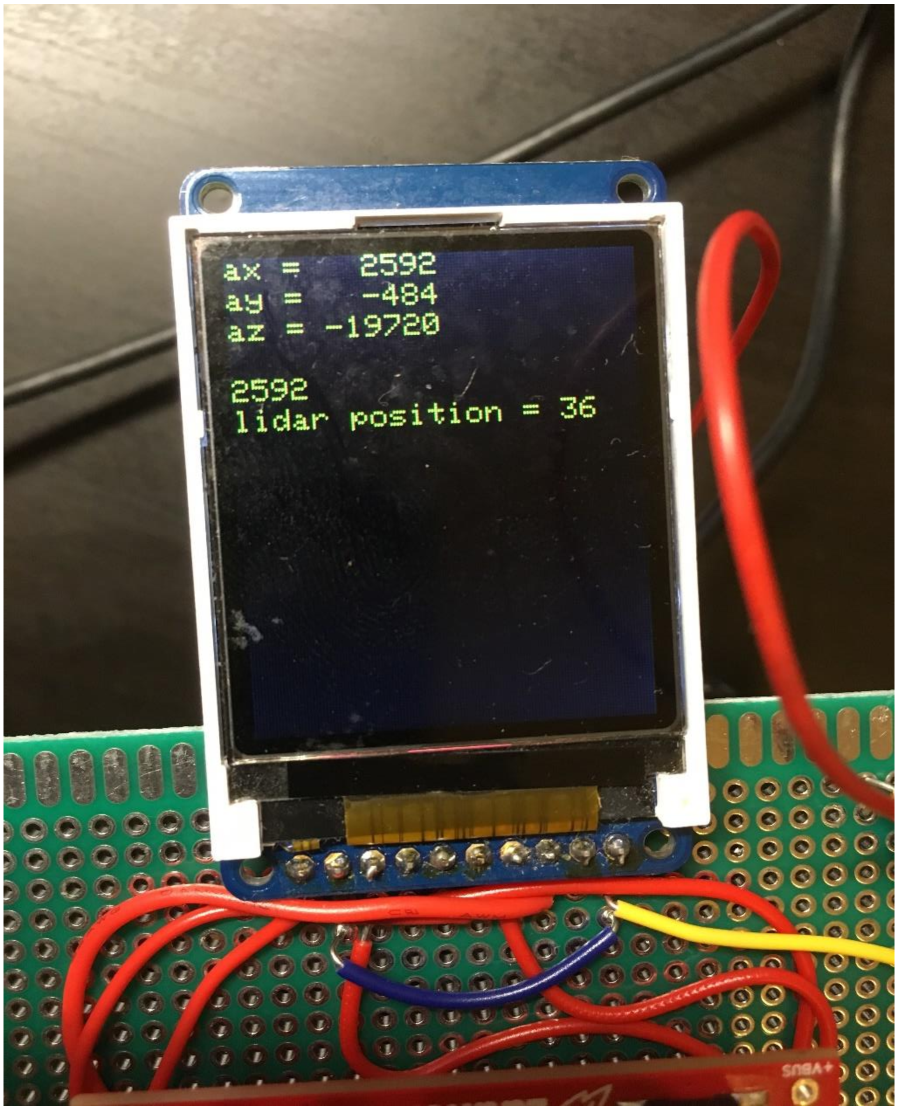
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