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ELEC 327 Midterm Report

The Game Table

Link to Demo: https://youtu.be/GtlVcza4X-o

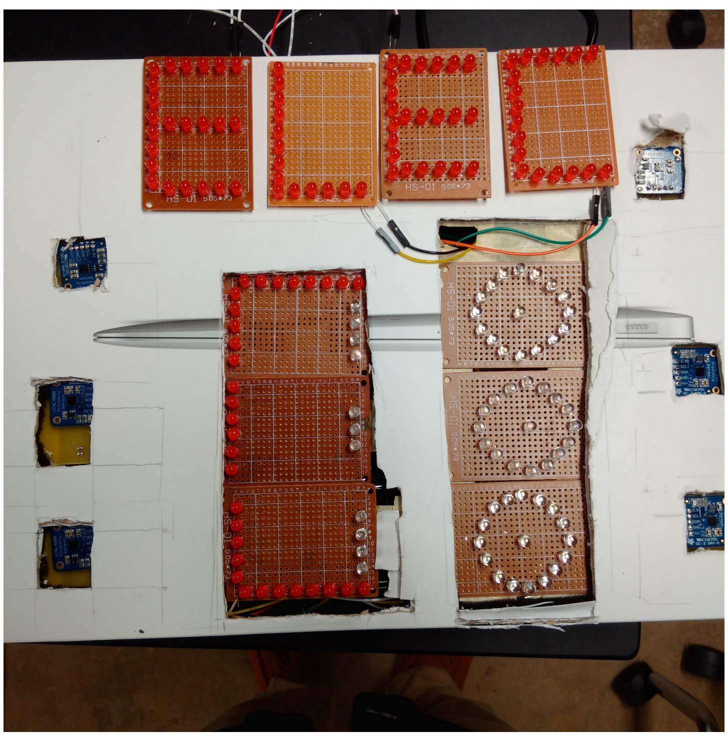
Part 1 - Design Story

At the beginning, we wanted to do the goal line technology. Datasheet of the sensor says it would work in a range of 20 cm. However, when we bought the sensor back, it only works in a range around 8 cm. Thus, goal line technology won't work well for our project. Thus, we plan to change our project to display some pattern using this sensor. The first pattern that comes into mind is "ELEC". We used four prototype boards; each board contains one letter of "ELEC". After that we want to use more LEDs to make a big table. But only making a table seems not very interesting. So, we want to incorporate other fun staff in our project. But, we don't want to use patterns again. We want to design a system that needs more interactions with the users. I was watching the game between Barcelona and Real Madraid at the monment. And Tianyi came up with this electronic soccer game idea. The game is a penalty kick win or lose game that needs two players to play. The balls, the goal and keepers are made of LEDs on prototype boards. As you have seen in class, when turned the light off, the patterns are fantastic. Also, I think the penalty kick idea is really interesting, even in the real world soccer game, penalty kick would be the most exciting part. Moreover, our project not only builds interactions between user and the system, but also between user and user. In the future, we could even develop our game board to multiple players mode.

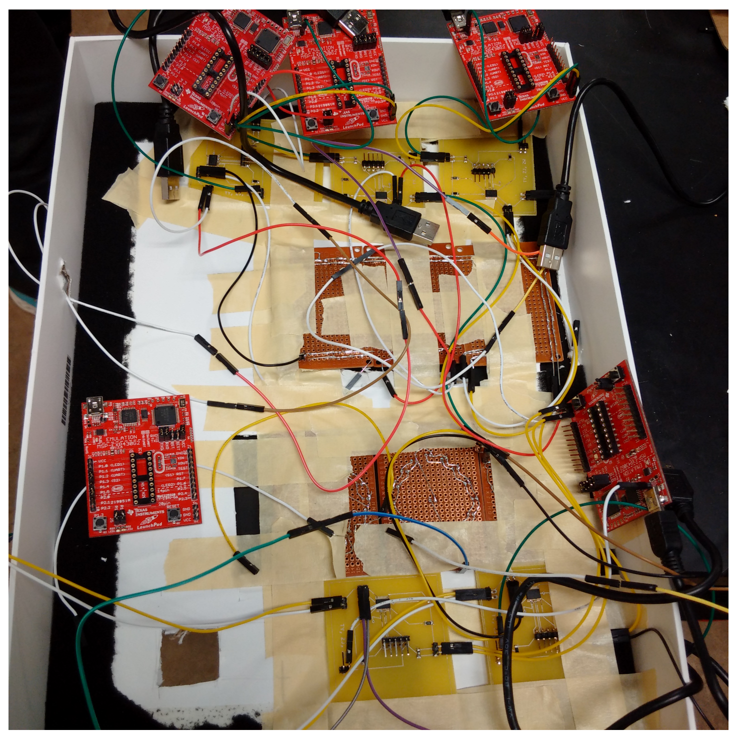
Part 2 - System Architecture

I. System Overview

Our entire system consists of six identical blocks and each block comprises of one portable battery pack (5V, 2A, DC output), one MSP430 launchpad, one PCB, and two LED pads. As the VCNL4000 proximity sensor requires both 3.3 V and 5 V constant voltage supply to function properly, we power the launch pad using the portable battery pack and the Vcc and TP1 pins on the launchpad provides 3.3 V and 5 V power supply respectively. Moreover, the VCNL4000 sensors senses both proximity of objects and the ambient light intensity and in turn produce two output signals. Therefore, each of the six sensors would drive two pads of LEDs. More specifically, the output corresponding to the ambient light intensity is used to drive the four letters "ELEC" and the goal itself. Hence, when there is no light in the surrounding environment, the letters and the goal will light up gradually due to the PWM functionality. Additionally, the output corresponding to the proximity is used to drive the three "soccer balls" and three directions in which the goalkeeper can kick out the incoming soccer ball. When the player puts his/her hands on one of the sensor, let's say one of the three sensors controlling the "soccer ball", the "soccer ball" will light up and indicates that the ball will be kicked in this particular direction. A top-angle view of our system configuration is shown below:



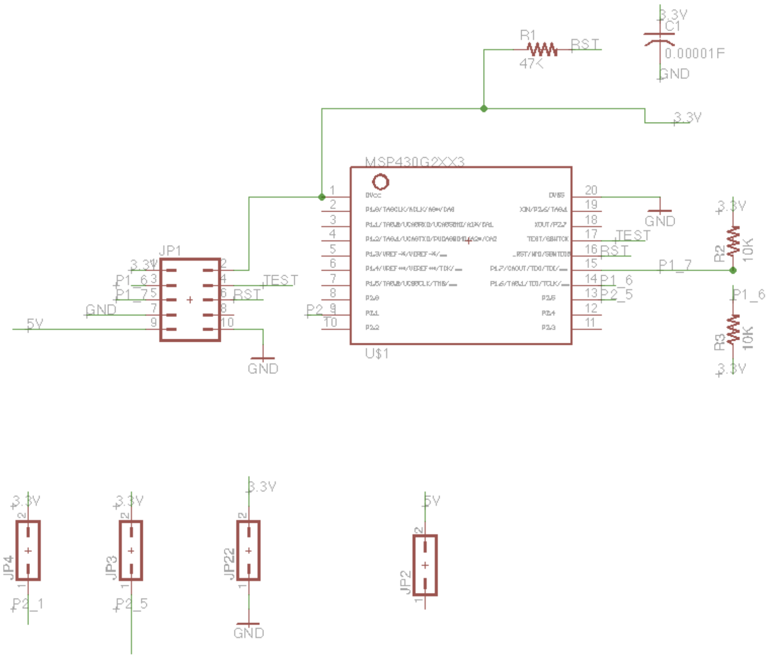
Top of the Game Table

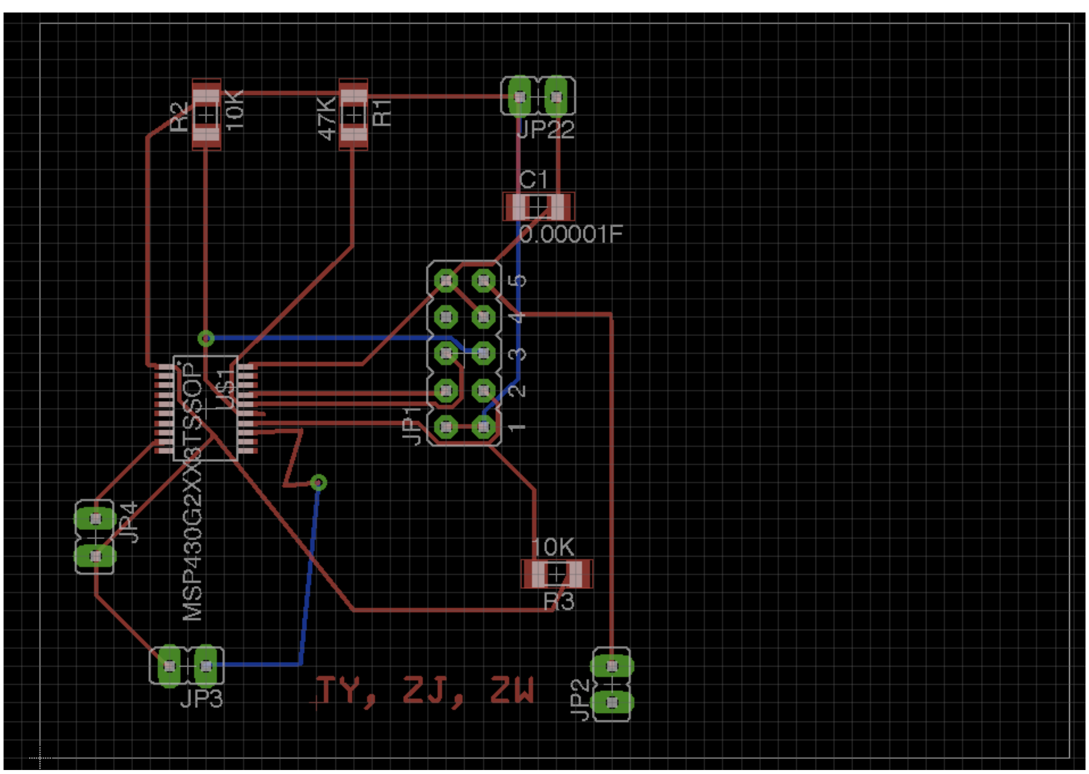


Back of the Game Table.

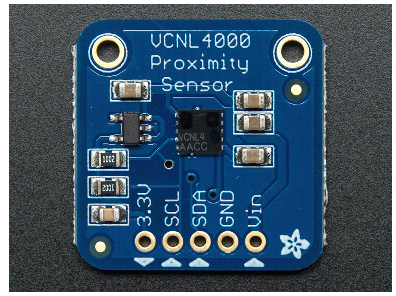
II. the PCB

Below are the schematic and board layout of our PCB.





III. the sensor - VCNL4000



VCNL 4000 is an integrated proximity and ambient light digital 16 bit resolution sensor. In our code, we set the proximity and the ambient light logic and levels in Energia. After that, if we block the light source or turn off the light, LEDs connecting to the ambient light channel will become brighter and brighter. If we unblock or turn on the light, these LEDs will become dimmer and dimmer until totally off.

Also, if we use something (such as our hands) to proximate the sensor, LEDs connecting to the proximity channel will become brighter and brighter. If we move the thing away, these LEDs will become dimmer and dimmer until totally off.

The VCNL 4000 uses I2C communication. It acts as slave when communicating with MSP430. The fixed slave address for the sensor is 13h.

When writing to the sensor, we need to choose the slave address 13h; then denote the read/write bit as write. After that, we need to choose the address of the internal register of the sensor, which we want to write to. And finally, we send the data that we want to write.

The reading process is more complicated using I2C. When reading from the sensor, we need firstly write to the sensor. First, we choose the slave address, denote write; then choose which internal register that we want to read from. Next, we must choose the slave address again, and then denote read/write as read. We do not need to choose the internal register address again. We can directly read the data from the specified register now.

Part 3 - Implementation Detail

Timeline:

- Spring Break
    1. programmed the I2C protocol
    2. tested the effective range of the VCNL4000 sensors
- Mar.7-Mar.10
    1. prototyped the entire system on breadboard

2. finished designing PCB layout

- Mar.11-Mar.24
    1. assembled all six PCBs
    2. designed LED patterns
    3. soldered all the ten LED pads
    4. put the entire system together on the cardboard
    5. prepared the video trailer and the live demonstration

Part 4 - Challenges / Self-criticism

The challenges in this project mainly come from its complexity. We have 6 PCBs, 6 sensors, 6 launchpads, 10 LED prototype boards, approximately 150 LEDs. Every single component needs to work for the entire system to function properly.

- The LED board is difficult to solder. Each LED board consists of approximately 20 LEDs, and they are all in parallel. We sometimes rotate the LEDs to make the pattern look good, but on the back of the board the wires can be extremely confusing, especially when the legs of the LEDs are all cut off. Two of the three soccer LED boards were not functioning at first, and we spent a lot of time trying to figure out whether there has been a bad LED or there was an LED with wrong orientation.

- The PCBs were difficult to solder and debug. Overtime, soldering the tiny MSP430 on the PCB became less and less of an issue, but some of the boards had problems that took us long time to debug. For example, there are times when code is up and running in MSP430 on the PCB, but the sensor is not responding to either proximity or ambient light, and therefore the LEDs are not turning on and off. Eventually we re-soldered MSP430s on all the broken PCBs until all of them were functioning.

- The box / table was difficult to assembly. The night before the demo we spent 4 hours putting everything together. We were thinking very hard how to make the table look good with only one box and the raw materials. We decided to put everything under the hood — inside the box — except for the four LED letter boards (“ELEC”). We cut blocks on top of the box so that the sensors and other LEDs are visible, while the boards containing them are underneath the surface and are not visible. The box perfectly hides all the wires and launchpads, and our table looks good on the outside.

We think that what's under the hood could be more organized, and it would be nice if the battery packs are replaced by a charger that can connect directly to power outlets. In this way, people just need to plug in to use the table, and there is no need to plug and unplug 6 USB cables, if our project is to become a real product. Nevertheless, we think that our project fulfills everything that is asked for in this midterm project. We had more than 1 PCB and more than 1 sensor. We figured out how to use interrupts and low power mode with the sensor, which we had no success finding such use online. We had the complexity that is probably a bit beyond the requirement. We also thoroughly described the technical details during the presentation, including how does the sensor works and how does I2C communicates with MSP430. Most importantly, our project is functioning perfectly, and our in-class demo has also been very successful. Our video also proved to be one of the most artistic and impressive video demos in the entire class. Overall, we would like to give full credits to our project.