# Juggling Balls with Pattern Recognition

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Introduction

The goal of this project was to develop juggling balls with an embedded system capable of determining the current juggling pattern and changing color accordingly. Each ball contains a small microcontroller, a three-axis accelerometer, and an RF transceiver.
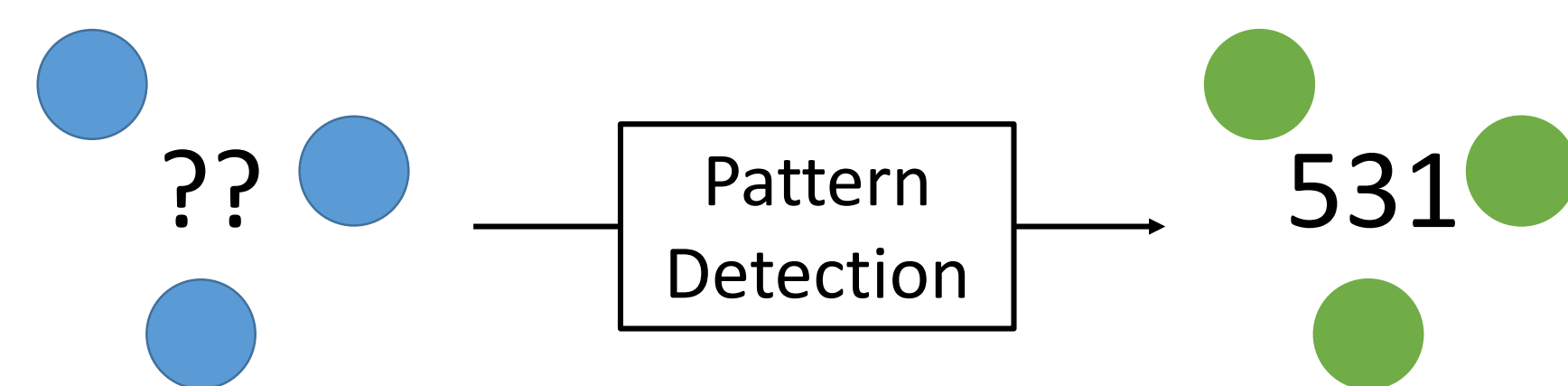
A variety of pattern detection algorithms were implemented with varying results. PCBs were designed to increase reliability and to ensure the hardware could fit inside the plastic sphere.

Siteswap

Siteswap is used "to keep track of the order that balls are thrown and caught" (Knutson, 1993). Space-time diagrams (Figure B) are useful for visualization. A throw is labelled "N" if N-1 throws occur before that same ball is thrown again. It can be helpful to think of the number as representing the height of the throw (Figure A).
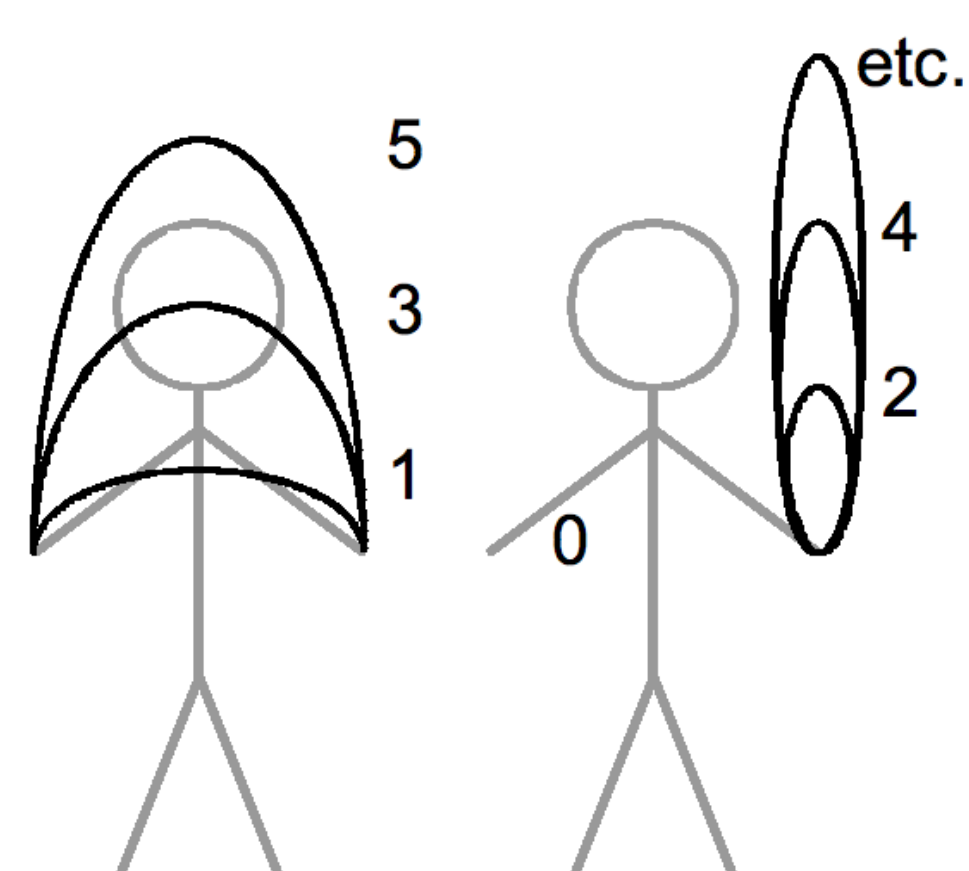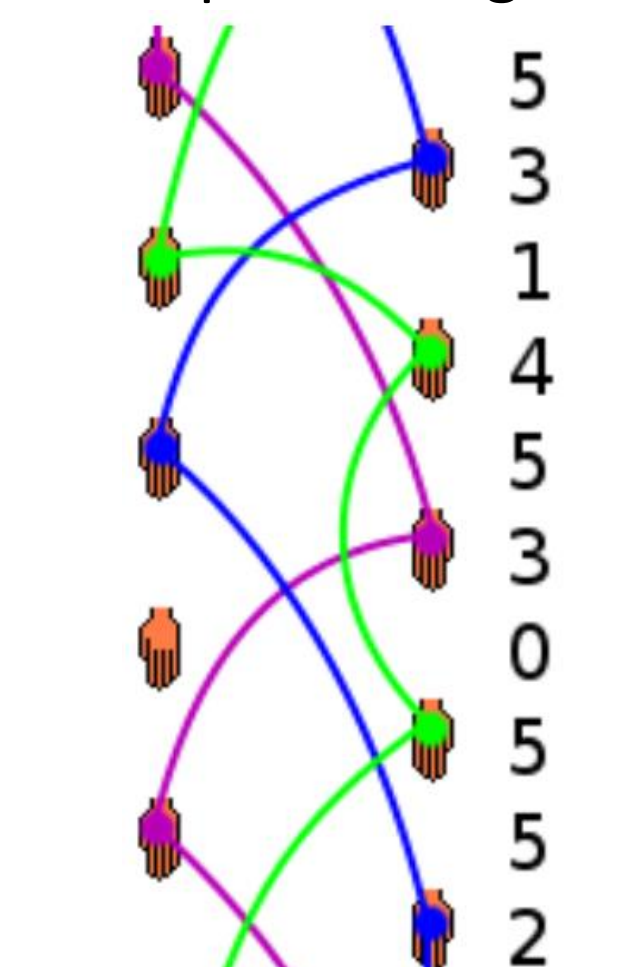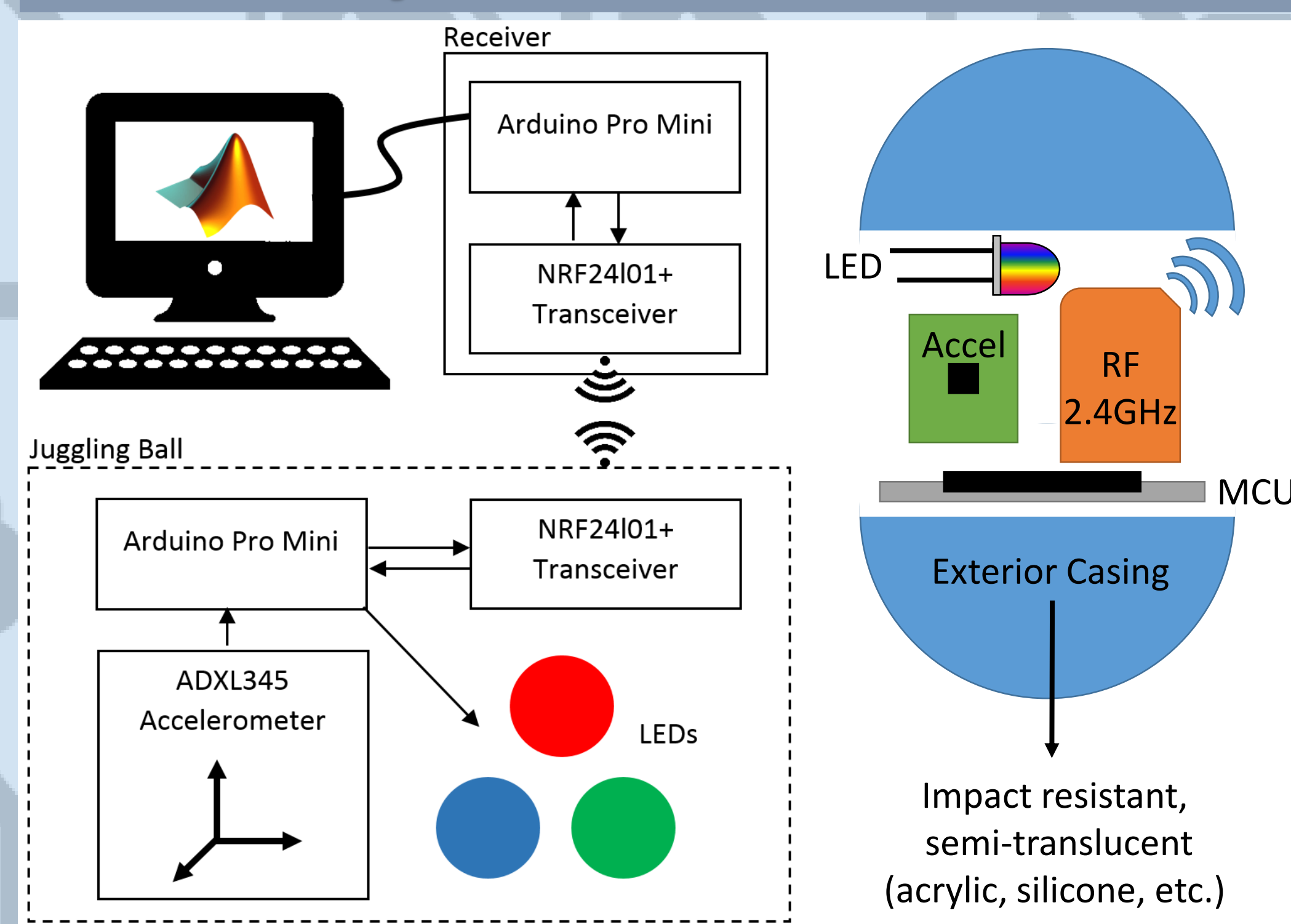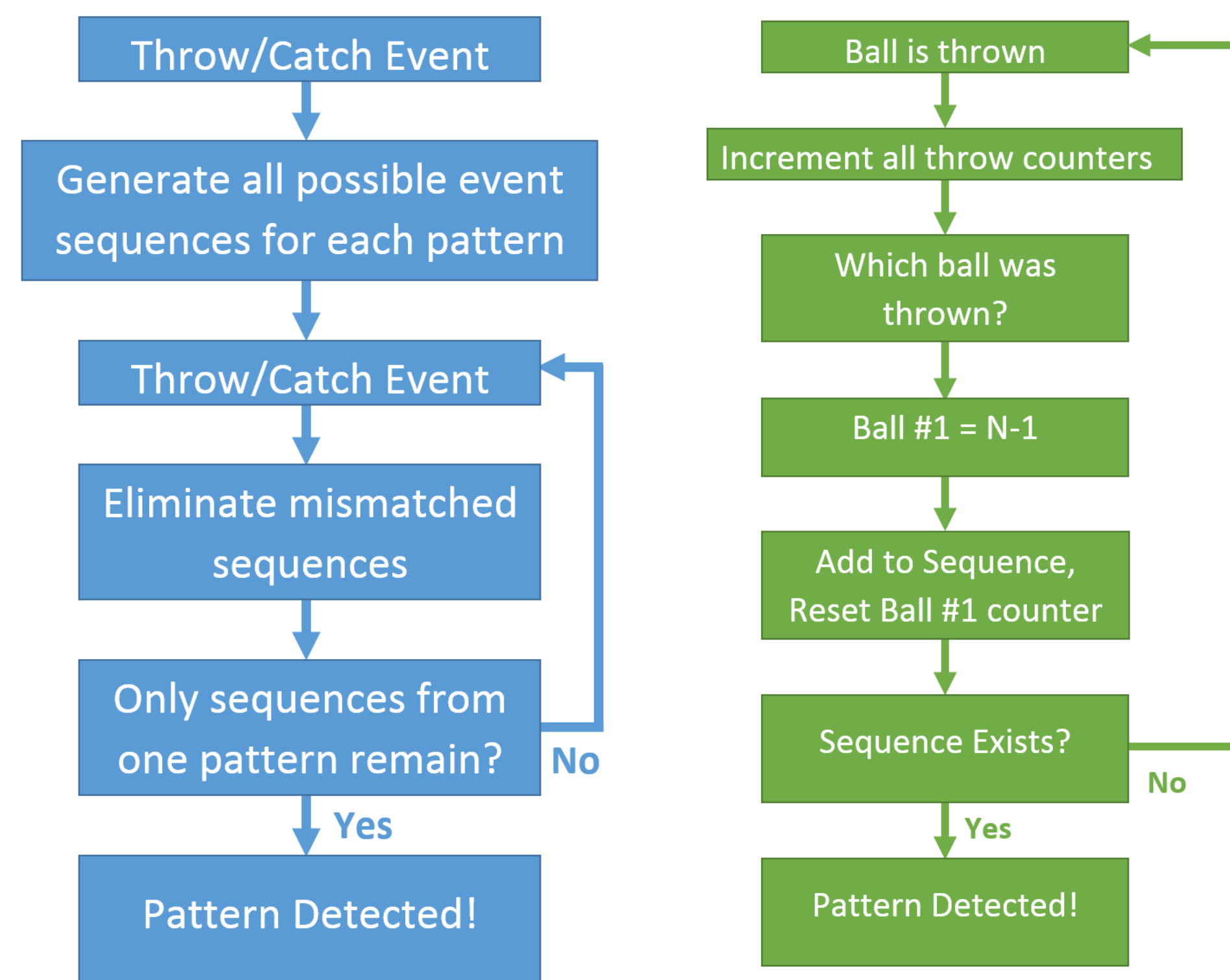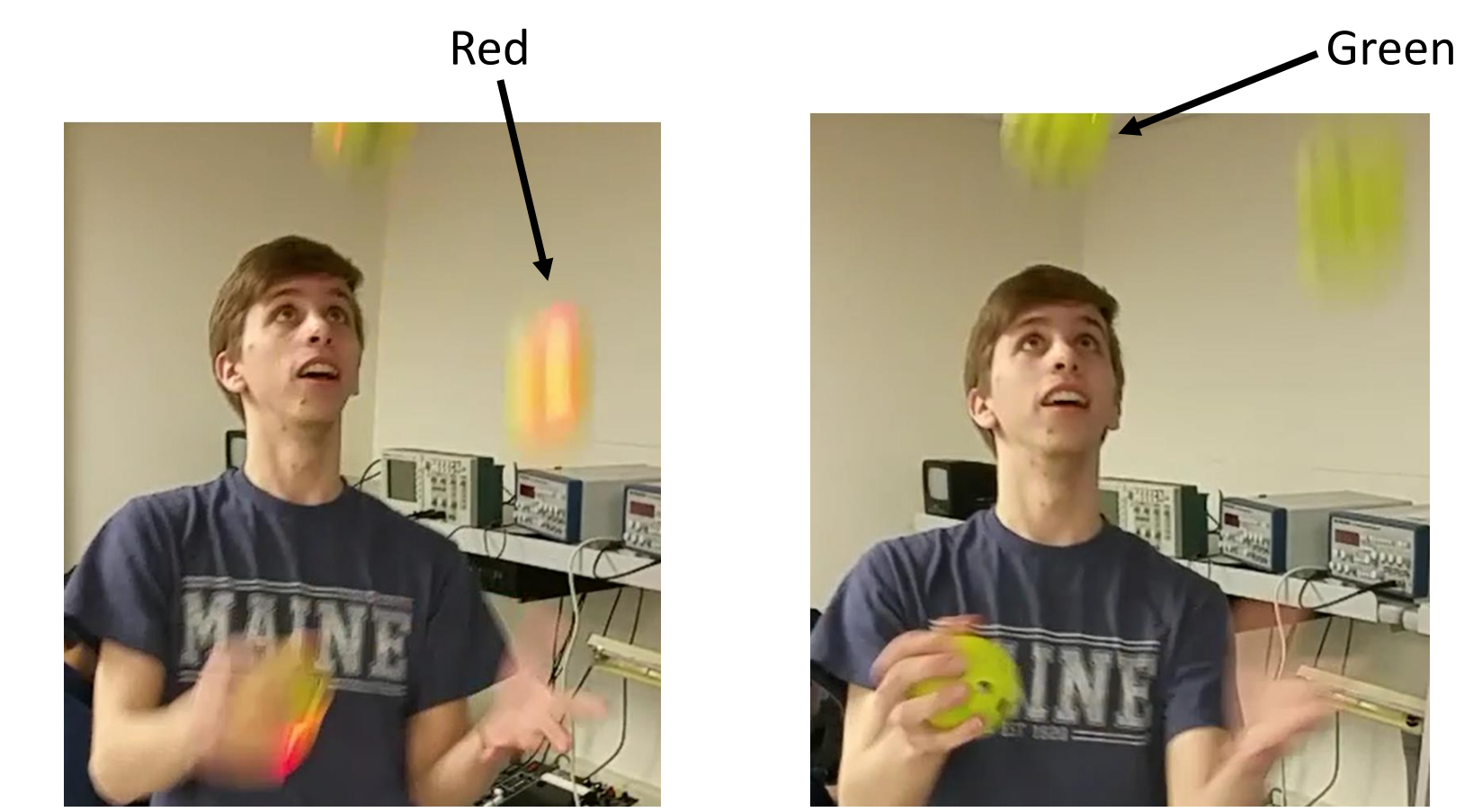
Fig. A Siteswap height

Fig B. Space-time diagram

System Overview

Receiver

Arduino Pro Mini

NRF24I01+ Transceiver

Juggling Ball

Arduino Pro Mini

NRF24I01+ Transceiver

ADXL345 Accelerometer

LEDs

LED

Accel

RF 2.4GHz

MCU

Exterior Casing

Impact resistant, semi-translucent (acrylic, silicone, etc.)

Pattern Recognition

Throw/Catch Event

Generate all possible event sequences for each pattern

Throw/Catch Event

Eliminate mismatched sequences

Only sequences from one pattern remain? — No

Yes

Pattern Detected!

Ball is thrown

Increment all throw counters

Which ball was thrown?

Ball #1 = N-1

Add to Sequence, Reset Ball #1 counter

Sequence Exists? — No

Yes

Pattern Detected!

Results

Red

Green

Pre-detection (3 -> 51)

Post-Detection (51)

We achieved fast pattern detection for 3 siteswaps (3, 51, 531). The balls change color once a pattern is recognized and confirmed. Faulty events delay the pattern recognition, however, this occurs less often now that the balls are more securely fabricated.

Future Work

Increase portability by moving the pattern detection onto the microcontroller. This system could support up to six balls which would greatly increase the number of available patterns for detection. Of course, juggling six of these is no easy task.

Finally, the addition of RGB LEDs would enable more color options to match the increase in available patterns.

References

[1] Knutson, Allen. Siteswap FAQ. Nov, 1993.
http://www.juggling.org/help/siteswap/faq.html

[2] NRF24L01+ Libraries from ManiacBug
https://maniacbug.wordpress.com/2011/11/02/getting-started-rf24/
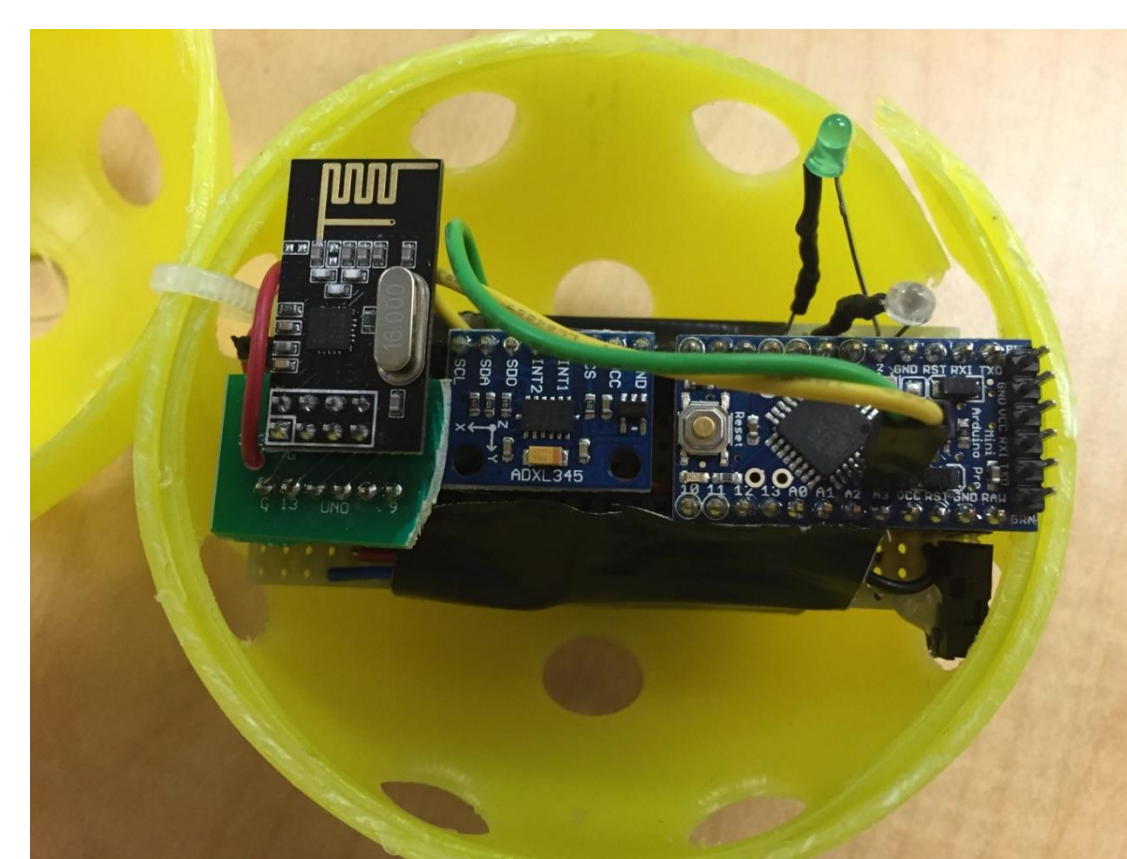
Prototyping

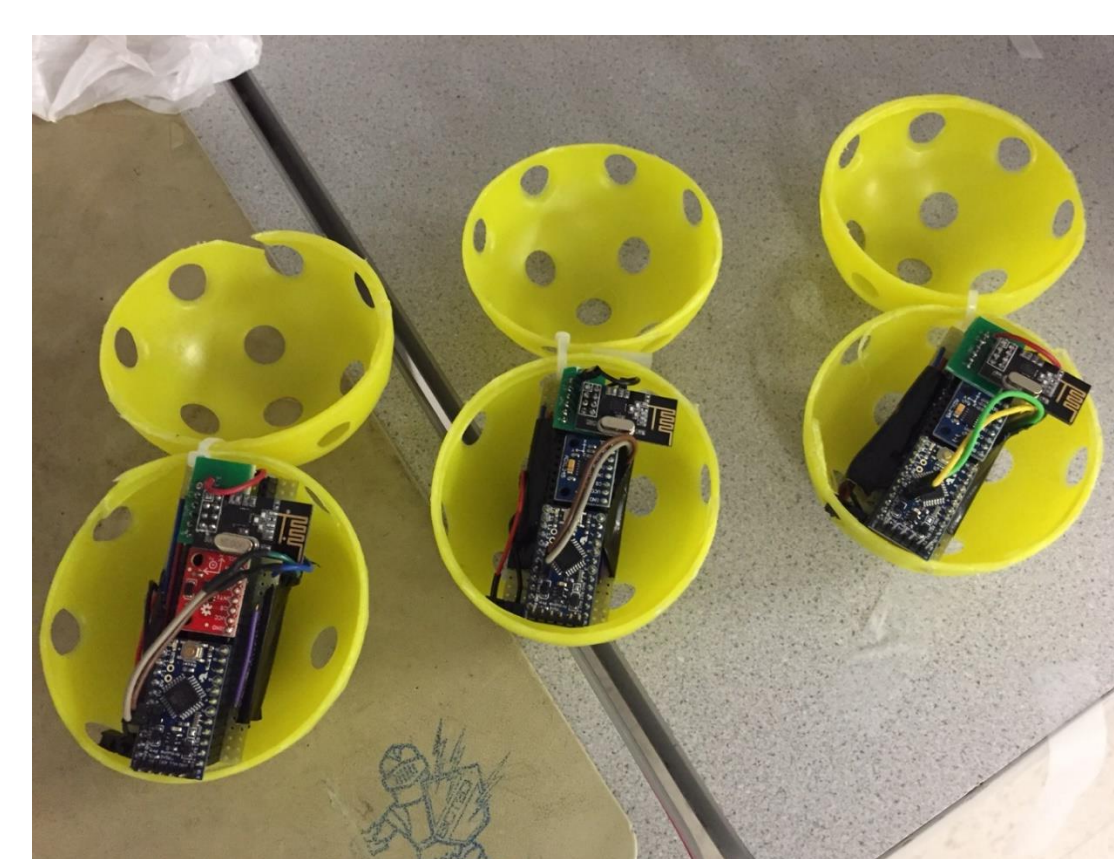Figure 1. First prototype, inside plastic softball. Powered by 9V battery.
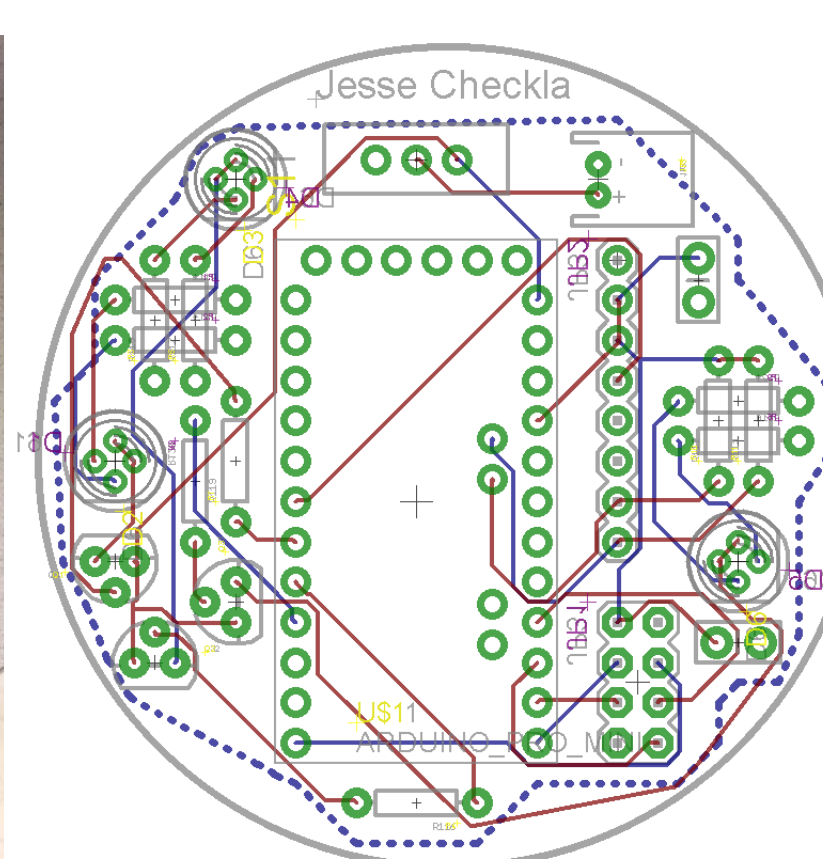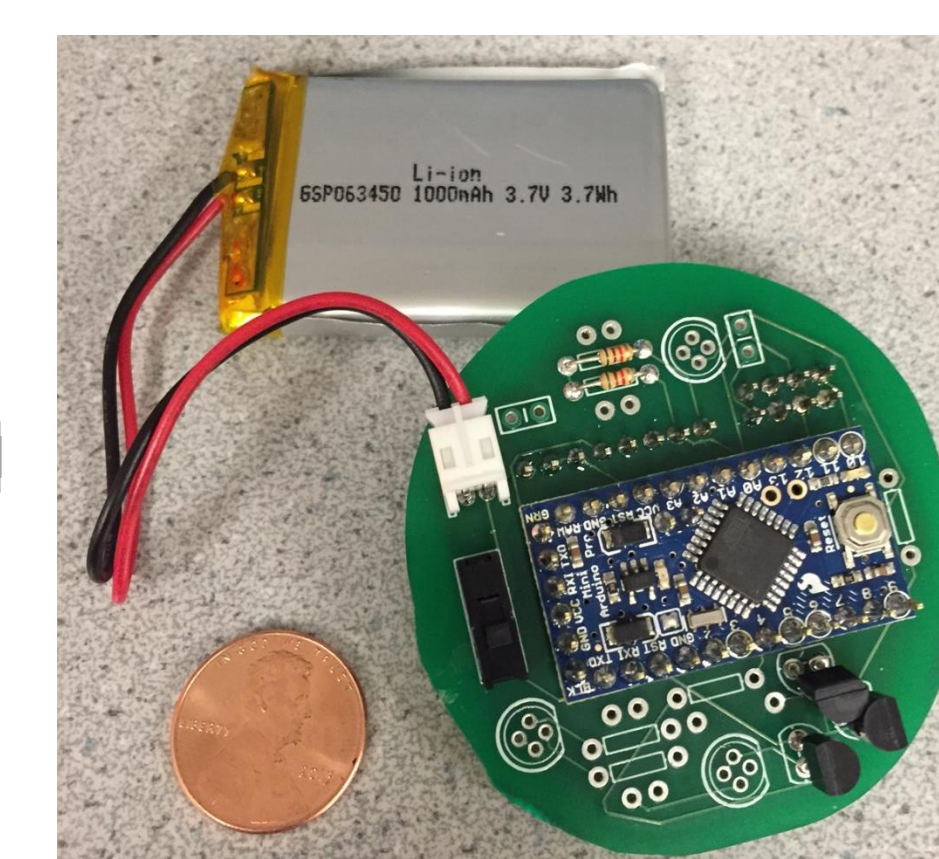
Figure 2. Three balls of first prototype.

Figure 3. Printed Circuit Board.

Figure 4. Final Prototype, LiPo powered.