

# BOXES

21M.734 Final Project

A photograph of a dark room. In the center, there is a bright, glowing opening that looks like a doorway or a gap in a wall. The light from this opening illuminates the immediate area around it, creating a stark contrast with the surrounding darkness. The floor appears to be carpeted, and the walls are dark, possibly made of wood or concrete. The overall atmosphere is mysterious and dramatic.

victor hung • may 12, 2014

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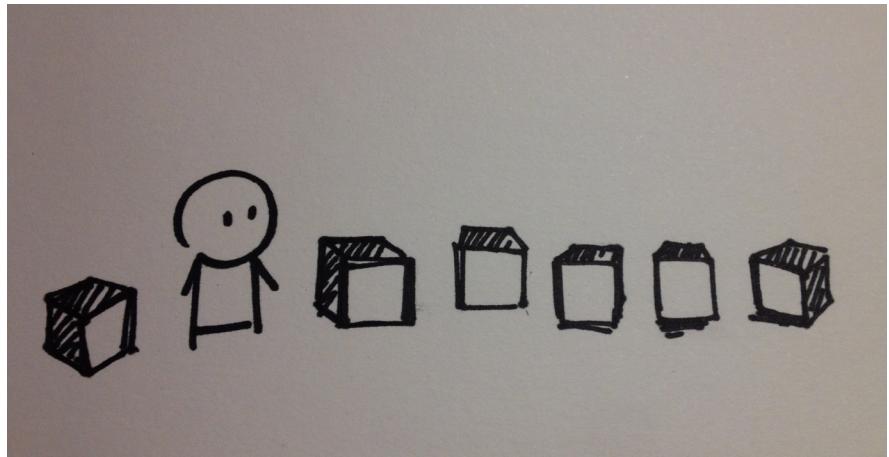
# STATEMENT OF OBJECTIVE

Up until quite recently, I've held the belief that 'good' lighting, particularly in theatre, is strictly lighting that seems so natural the audience fails to notice it. With this project I aim to do the exact opposite - not just to have people take note of light sources, but perhaps to have them interact with the lighting. Amidst the busy lives of everyone at MIT, one exciting attribute that still prevails is curiosity, frequently sparked by a little technology turned magic.

One of my passions is user interaction and user experience. I weigh these things quite heavily with anything that I do. BOXES is a series of light boxes that can react to people in different ways. Each box has a set of RGB LEDs to provide millions of different colors, and is programmed in different ways to interact in different manners.

# INITIAL CONCEPT

The initial focus of this project began as an exploration of human interaction with light. Each box would be given a personality, and, though it may not seem immediately apparent to nearby people, the boxes light up and change brightness and colors based on their personality. A sensitive box would quickly change red whenever perturbed (i.e. the box was shaken, moved, or touched). A more relaxed box would have a pulsating cool blue heartbeat. Shown on the right is a drawing that depicts six of these boxes, and me.

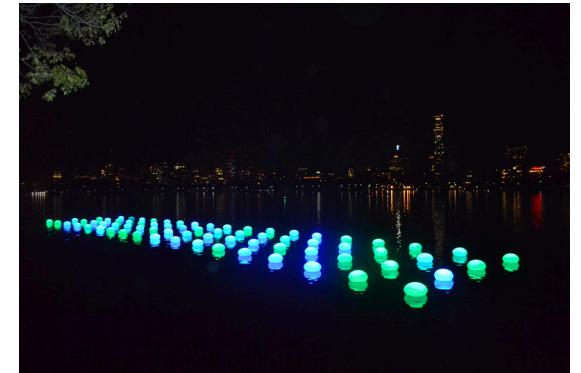




A lot of the initial inspiration came from art projects that I had simply seen around campus. People naturally attempt to reason behaviors, or if curiosity is a big enough factor, figure out how something works. With this, I wanted to do it in a cute and appealing manner. I've had previous experience making mechanisms, robots, and inanimate objects 'cute', so could I do the same for lighting? But also - where does that line between treating something as an inanimate, rule-based object to having a 'personality'?

**Figure 1a.** In the left most picture is a box appropriately named Mike that changes brightness and color based on the audio input. **Figure 1b.** Eric is a bandwagoner, so its brightness is based on the brightness of the surrounding ambient light. **Figure 1c.** Josh is a box that constantly glows a Twitter Blue who's brightness changes based on the amount of twitter activity nearby.

# VISUAL & TEXTUAL RESEARCH

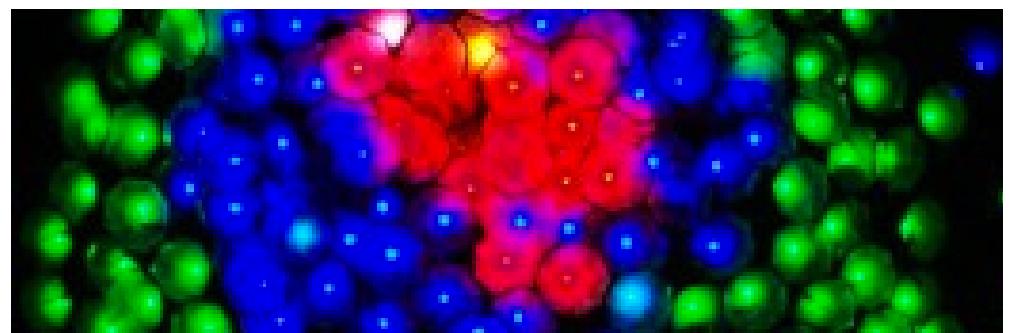


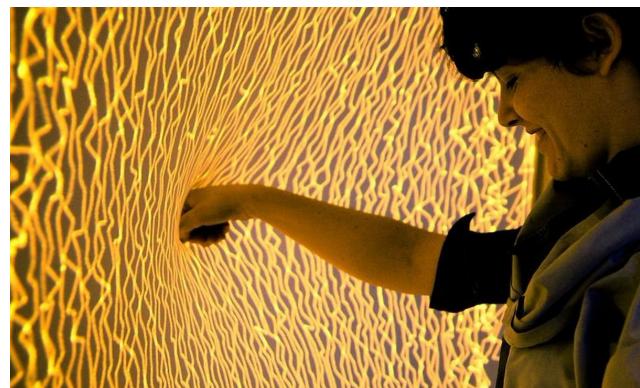
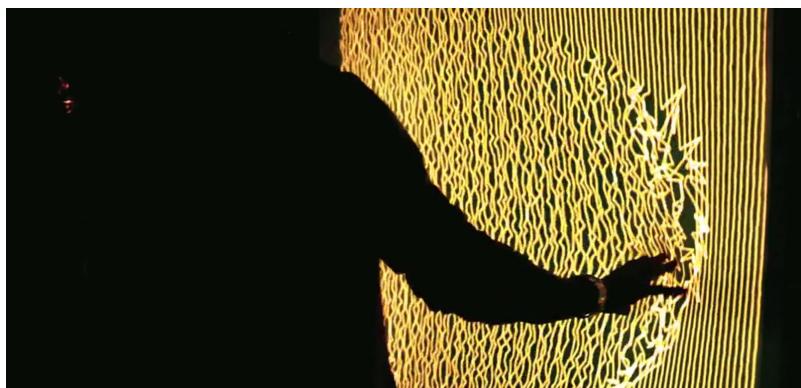
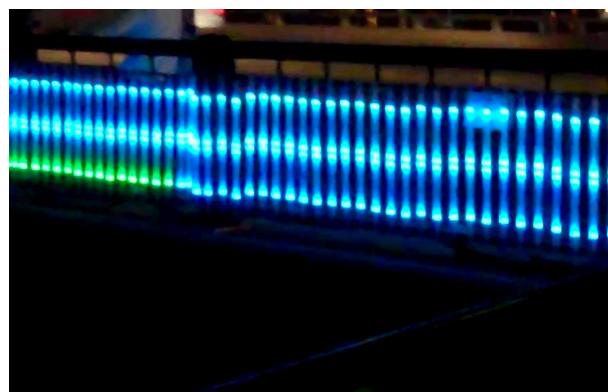
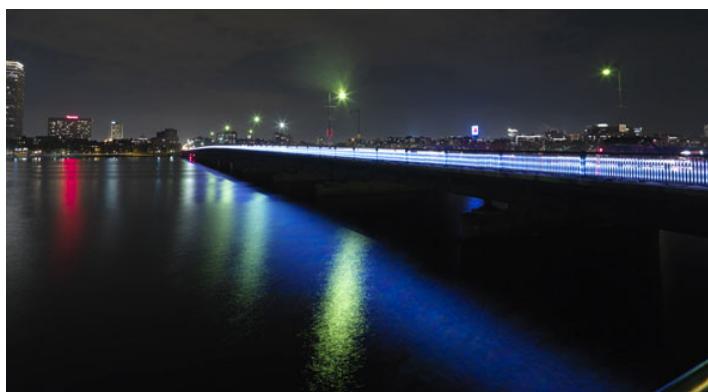
**Light Drift** is an interactive art installation by Meejin Yoon that connects brightly colored glowing orbs on a water to a similar set on the shore or river's edge nearby. "The orbs on land use sensors to detect the presence of a person and relay a radio signal to the corresponding orbs in the water, allowing visitors to transform the array of orbs in the river [...] Multiple viewers can create intersections of linear patterns"



**CLOUD** is an interactive installation by Canadian artists Caitlind Brown and Wayne Garret. This display invites visitors to stand beneath the collection of light bulbs that form this 'cloud' and collectively make it flicker and pulsate by pulling on cords to dim and illuminate thousands of individual light bulbs.

I drew a lot of initial inspiration from interactive light installations that took beauty in the ambiance of interacting with light, and using light as a simplified medium for people to interact with one another. With BOXES, I wanted people to be directly interacting with light.





# TIMELINE

- 04 / 17 Initial Research & Preliminary Designs
- 04 / 21 Circuit Design and Prototyping First Box
- 04 / 24 Software Design and Testing
- 04 / 27 Implement Basic Commands
- 05 / 01 Complete First Box & Exploring Interactions
- 05 / 03 Create Additional Boxes
- 05 / 05 Exploring Multiple-Box Interactions
- 05 / 06 Record & Edit Video
- 05 / 08 Setup Demo with Video Display

# JOURNAL

## April 17

Today I looked at some different initial designs for doing what I wanted to do. Most notably, how to provide the LEDs with enough power and a choice of drivers. I'll be controlling the LEDs with a microcontroller such as an ATTiny2313, and I'll be using the NRF24L01 Chip for wireless communication between the box and the computer. Below are some rough milestones.

Tuesday, 4/21

Electronics designed, tested, and prototyped  
Coding begins - ideas & interactions explored  
Sunday, 4/27

Code fully implemented.

Thurs, 5/1

Video recorded

I'll be using the long weekend to test a lot of this out- and to play around with what I have to work with before ordering more parts. I also plan on now making a simple version with one box, being able to interface with the box with the software I'll write, and grow/work from there.

## April 24

Aquired all the materials except for the every NRF24L01 Wireless chips. The ones I ordered

off ebay are terrible, and the ones that ended up working are the SparkFun chips (which I only have 2 of).

I began breadboarding, but I won't have any idea of whether or not what I'm doing will work until I write the software for communicating wirelessly.

## April 27

Over the weekend, I got a majority of the wiring and coding done for the First Box! I also quickly built a transmitter and tested it, and I can control one channel of RGB! Hooray!

## April 29

Sent a lengthy email describing some of my struggles:

Unfortunately, I ran into quite a lot of problems to get here- mainly the electronics and positioning the LEDs so they give an even glow.. but I'm quite happy with that now.

that being said, I'm running a little low on time, and I was hoping to use more of this opportunity to, instead of producing 8 boxes like i had intended to, stay with 2-3 boxes and spend more time exploring what kinds of things I can do with this/ways people can interact with this. I've thought a lot about how I can create different things with this,

and how I can use this light to as a medium of communication between people.

I've also thought about what you said in terms of 'an incentive to interact with these boxes beyond just curiosity'. This stuck out to me a lot, because this curiosity is something I really want to try to bring out in people, and show this somehow.. but I'll continue thinking about this.

Anyway -this was different from what I had initially talked about in my midterm report.. I was just wondering if this is alright? I'll be documenting all the things I do/experiment.



## May 1

Went and picked up some more wireless communication chips.

I've been thinking a lot more about how people would 'interact' with these boxes. There's

always the problem of setting out something that motivates one to do something, but is open ended enough such that the outcome is interesting.

In terms of the actual design/production of the boxes, I've fully completed one.

This one is now fully controllable from my computer, and it's set to a lovely orange-amber glow. Hooray! Here is a video of someone my friend messing around with the box. It's set to flicker randomly, amusingly emulating the flicker of a TV when you sit in front of it.



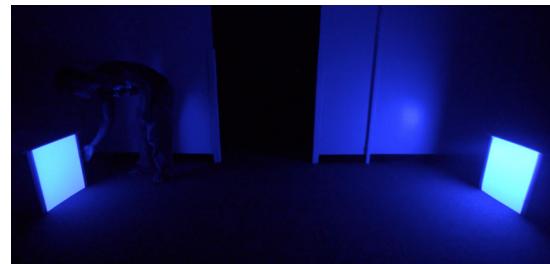
## May 4

Built 2 more boxes. Also expanded wireless protocol to be able to handle more boxes.

## May 6

Had a couple more ideas and decided to implement them with software. I'll be attaching an input element (just a simple button) to each of these boxes.. except each box's button controls another box. This input element can

be used for other purposes too, and hopefully can help be one of the more clear ways people can interact with BOXES.



## May 7

The night of, I placed 3 of these boxes in the common area of my dorm, and left them there for an hour. The interaction for this one was simply that the boxes would light up green as people approached them, and slowly fade away when people left. If someone were moving really fast, it would glow more of a red color instead of green.

I achieved this by placing a camera a fair bit away from the normal walking path of residents such that I can analyze the motion and automatically determine the brightness of the boxes. I left another camera there that recorded the reactions.

This elicited more responses than I had expected, which made me quite excited. I think this came from the fact that there was the mystery of 'how this was being done'. As I worked on another project on the side, away from these boxes, a friend who had passed by came up to me and asked if I was controlling

the boxes from where I was sitting. I satisfactorily replied 'no'. There's a little bit of this magic that comes with any clever piece of technology. This is something that means a lot to me, and to have people playfully interact with these boxes means I was able to achieve my initial goals.

I also edited and put together a video using clips taken from tonight, which will be my 'demo' video.



## May 8

In class today, I found a monitor and thought about how I would be displaying my project. Initially, I had not wanted to bring these cubes in, but having found one cube at Rinaldi that had an open bottom, I decided it might be cool to bring in the electronics and to have a little demo with just one cube.

I marked an area where I would set up this cube. I plan on running the demo where it would glow green as people approached it, and glow red when there was a large crowd of people surrounding it.

## **May 13**

This morning, I precut one piece of the polyethylene sheets in my room. I also made another set of electronics. I brought this over to Rinaldi and then created another BOX using one of the black boxes at rinaldi that didn't have a bottom. It was quite spectacular - even better than the boxes I have in my dorm. These black cubes are actually cubes, and to make it look even cooler, I added a rim of black gaffer's tape such that there is an equal border around each side.

I had initially set up near the miter saw, but it just didn't seem exciting. The whole purpose of these cubes was lost when it became a 'display', and I lost that feel of being able to casually interact with them. The TV sitting there playing my video was just fine.

After a short while, I decided to move the cube into the classroom, putting it on a shelf hiding it amongst some tools and hardware.

This was a wonderful idea. It sat comfortably amongst a mess of things, and it really came to 'life' as it lit up. It was also activated when someone walked into the path leading into the classroom, so the effect was immediately clear and it glowed as people approached it.

## RE-EVALUATION

BOXES initially began as a project to create a set of simple lightboxes with personality. Throughout this process, it became more interesting for me to see how people interacted with these lightboxes and to observe the emotions that the boxes invoked.

An early test with a couple of my friends made clear that these boxes had a lot of potential and could represent a variety of feelings and ideas. To grow an attachment to them in a way that anyone could ever grow an attachment to an inanimate object was a different story. Instead, I decided to attempt to tap into the curious nature of individuals and use that to trigger a response.

BOXES then became an exploration of these feelings of people, and the feelings elicited from these boxes. At first, people thought they were mysterious in a light comical manner - each having a button that could only control the light on another box. And then they made people suspicious of them, almost like the internet trolls of the real world. People began to wonder how these boxes were clever enough to glow brighter as you walked towards it, and whether or not these boxes were watching them.

# PROJECT OVERVIEW

To create an installation that motivates human interactions with light and to elicit a response that is beyond simply understanding how something works.

As mentioned earlier, one of the aspects of life I enjoy the most is user interaction and user experience design. With that being said, I have an appreciation for simple and clean designs, and so I naturally chose to use these lightboxes as my medium. Without the noise and clutter of a lighting instrument, these lightboxes have one face that is semi-transparent panel that emits one single, diffused, color.

Next, looking at the wide range of possible motivations for interacting with these boxes, I really wanted to focus on curiosity. There is an abundance of that at MIT, and it's also one of the reasons why MIT students are often pinned as different from the rest of the world. A lot of people here enjoy being teased by something beyond their current set of knowledge, and enjoy this process of understanding and that spark of a sudden realization.

With this in mind, I wanted to create boxes that reacted when you walked near them. Unaffected by everything else, they glow brighter as you approach them, and, with three in a row, create this wonderfully rippling effect. Yes, this is a beautiful effect, but ultimately uninteresting. To me, the beauty and excitement appears when someone pauses mid-stroll, interrupts this flow and begins thinking: how do these boxes know? Is someone controlling this? Where are the sensors? This sense of discovery/exploration and going against the flow is how society advances (and aligns closely to my personal philosophies) - but that's another conversation for some other time.

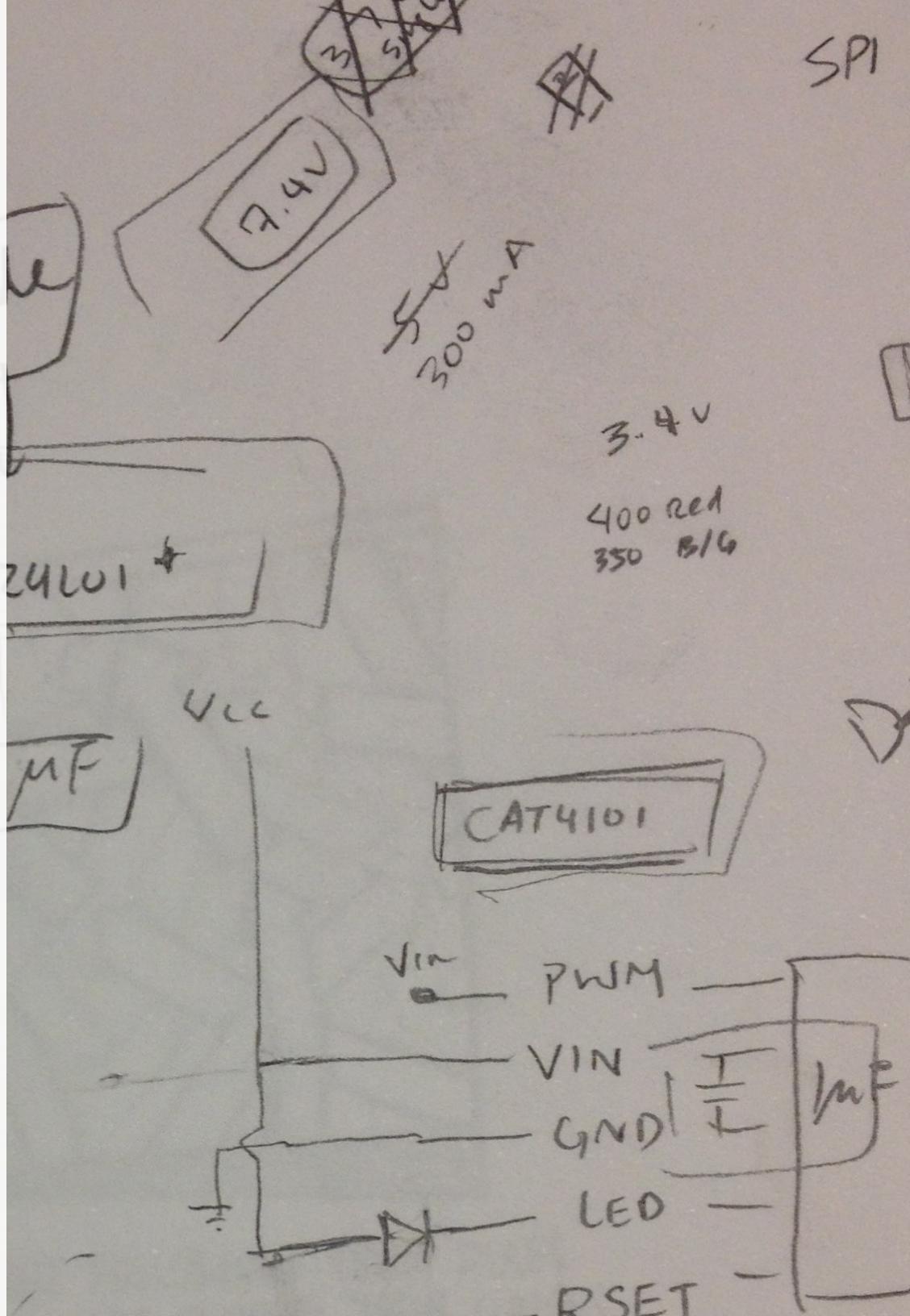
The ideal location to install this project is somewhere near a lounge or an area where people tend to stroll during their downtime. To maximize the number of people who could potentially interact with these boxes, I chose to display BOXES on the evening of May 5 and May 6 in the George Hosker Lounge of Next House.

# TECHNICAL DETAILS & MATERIALS

## Materials

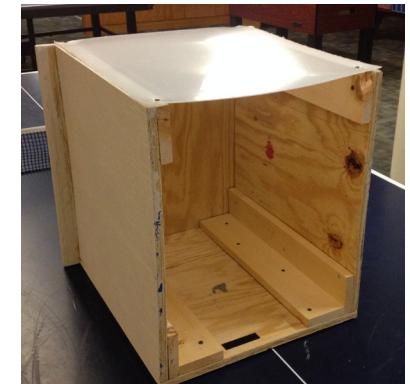
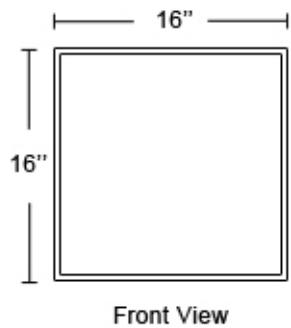
Per 1 Box

- 1 x BOX Assembly
- 1 x Polyethylene Sheet that covers one face of the BOX
- 2 x Vollong 3W RGB High Power LED
- 3 x CAT4101 Constant-Current LED Driver with PWM
- 1 x Arduino Uno
- 1 x NRF24L01 2Mbps RF transceiver
- 1 x 11.1V 3-Cell LiPo Battery 5000mAH
- 1 x Traxxor Battery Connector
- 3 x  $2k\Omega$  Resistor
- Bypass Capacitors
- Adhesive Velcro
- Red, Green, Blue, Black Wires
- Solder & Hot Glue



## Assembling the Box

Ideally, the boxes would be perfect cubes of 16" by 16". I was able to acquire boxes of similar dimensions that had already been built for another project. All I had to do was to cut an appropriately sized sheet of polyethylene as a semi-transparent face of the box so that light can glow through that side.



*Left:* Ideal box front view dimensions

*Middle:* Front view of box with panel

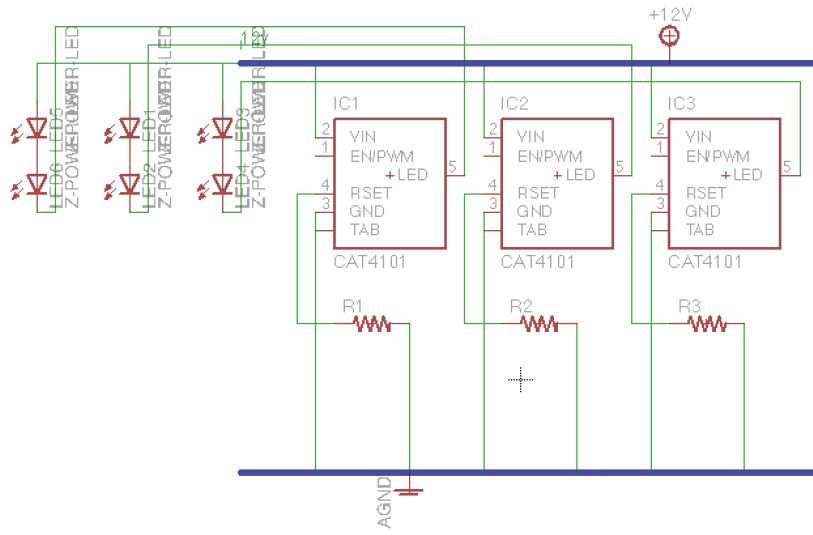
*Right:* Underbelly view of the box

# Connecting the LEDs to the Arduino

The schematic on the right shows the wiring of the 6 LEDs and the CAT4101 LED driver pins. These CATs are capable of driving these super bright LEDs, and can be controlled by PWM.

The CATs are adjustable current sinks that is set based on the value of RSET. I've chosen the RSET resistor to be roughly 2k Ohm, to provide a current of 300mA in each LED. With a 5000 mAH battery, these lights can be on full brightness for several hours!

Each of the CATs have a PWM in which is connected to a PWM out of an Arduino UNO. This arduino can be substituted for most Atmel Microcontrollers such that the entire assembly can exist on one printed circuit board.



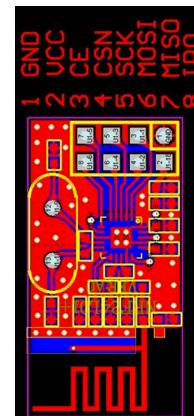
# Making the Arduino Wireless

The Arduino communicates through its SPI bus to the NRF24l01. For the receivers (the boxes), I used an Arduino library that had specified pins which connected directly to the NRF Chips (the table is shown to the right, along with the pinout of the NRF Chips).

Once these were connected, I also needed to provide power to the Arduino, along with power to the LEDs. Using a make-shift Traxxor connector (a slightly modified fuse - real traxxor connectors are expensive) I connected the ground to every ground and the 12v to the Cathode of the LEDs as well as the Vin of the Arduino

The NRF24l01 Data Sheet can be found on the Nordic Website  
<http://www.nordicsemi.com/eng/Products/2.4GHz-RF/nRF24L01>

The CAT4101 Data Sheet can be found on the ON Semiconductor Website  
<http://www.onsemi.com/PowerSolutions/product.do?id=CAT4101>



Signal	RF Module	COLOR	Arduino pin for RF24 Library
GND	1	Brown	GND
VCC	2	Red	3.3V
CE	3	Orange	9
CSN	4	Yellow	10
SCK	5	Green	13
MOSI	6	Blue	11
MISO	7	Violet	12
IRQ	8	Gray	

# Transmitter, Firmware & Protocol Design

The Transmitter was simply an Arduino with a NRF24101 that was programmed to be a transmitter. The pins were wired in the same manner as the same library was used.

The protocol for the lightboxes conconsisted of packets with 5 bytes each. The bytes are specified as followed:

BYTE1 : Sync Byte (always 0xAA)

BYTE2 : Command/Address Byte (see below for explanation)

BYTE3 : Value for RED

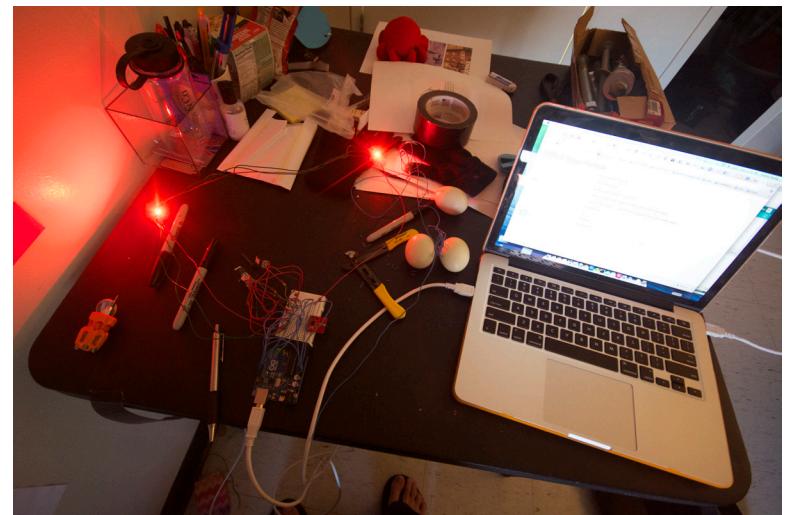
BYTE4 : Value for GREEN

BYTE5 : Value for BLUE

Byte 2 can either be the direct address of a box (e.g. 0x01, 0x02...) or a command to specify an instruction to modify all/some of the boxes at once. These commands were not used in for this project but exist as room for future expansion.

Bytes 3 - 5 are values between 0 - 255 that specify PWM values for the LEDs.

The firmware for this can be found on the stage-simple GIT Repository:  
<https://github.com/sjlevine/stage-simple>



Testing the leds with my laptop. The three eggs are for juggling when I hit a bug I can't fix.

# SIMPLE Stage Controller Software

To test the system incrementally and to be able to simply turn boxes on and off, I developed a program that executes simple commands. The interface resembles that of a manual, programmable cue list. This high-level program utilizes the base service code that communicates JavaScript commands to the Arduino, which sends data to the transmitter which broadcasts to the receiver.

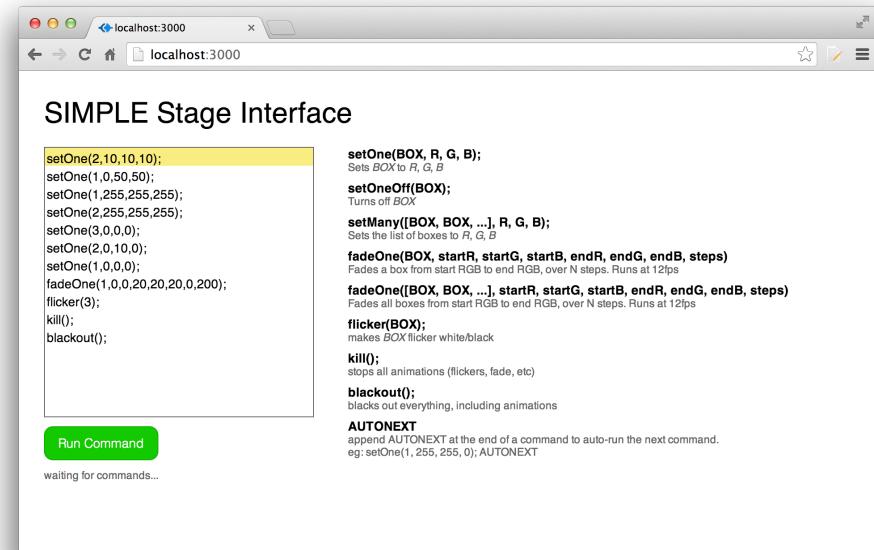
This program is built on Node.JS, a (traditionally) web programming framework which has been expanded to handle serial communication as well. I wrote this program such that a command like:

```
setOne(2, 10, 40, 0);
```

Controls BOX #2 by turning the RED value to 10, the GREEN value to 40, and the GREEN value to 0. I've programmed a variety of other programs that I thought would be useful in the testing and exploration of devices.

All the code for this, along with the code for the next few parts can be found on my GIT Repository:

<https://github.com/poofytoo/simplelights>



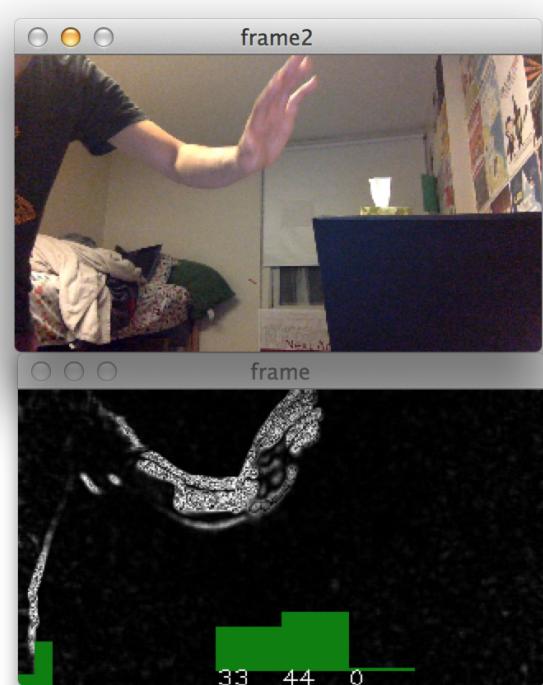
## BOXES Three-Box Software

The Three-Box Software is the piece of code that detects the movement of people and turns on the boxes as they approach them. This creates the rippling effect of lights when people walk by.

This is done by a camera capturing the scene, running image processing on it to detect and isolate the movement, and then calculating the amount of movement. This is then separated into three partitions horizontally, and each of the three boxes have brightness values that directly correlate with the amount of movement within each box.

In the screenshot to the right, I move my hand which triggers the first two boxes, turning them to values 33 and 44. In this example, the light boxes turn a delightful shade of green. The stream of text are actually the packets being sent by the transmitters (you can see the first byte is always 0xAA)

```
aa01000000  
aa02000100  
aa03000000  
aa01000000  
aa02000100  
aa03000000  
aa01000000  
aa02000000  
aa03000000  
aa01000000  
aa02000000  
aa03000000  
aa01000000  
aa02000000  
aa03000000  
aa01000000  
aa02000000  
aa03000000  
aa01000100  
aa02000000  
aa03000000  
aa01000300  
aa02000000  
aa03000000  
aa01000600  
aa02000000  
aa03000000  
aa01000d00  
aa02000000  
aa03000000  
aa01001400  
aa02000000
```



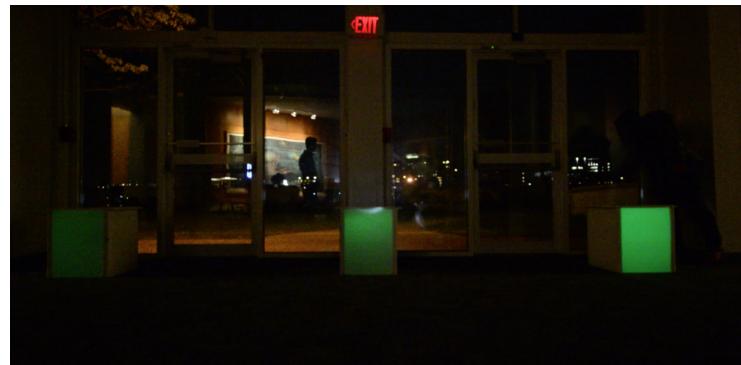
# FINAL PRODUCT

The final setup can be seen in the image to the right (when all the lights are on). The camera being used is on the screen-face of the orange laptop, and the connection coming out to the left of it is the transmitter.

The laptop monitor brightness was then turned all the way down, and the green light for the screen was then blacked out to make it nearly undetectable.

The result was then recorded and edited. This will be shown in class along with live demo of one of these boxes.

For reference, the video is here:  
<http://bit.ly/victorsboxes>





# SOURCES AND THANKS

## Image Sources

### *Light Drift*

<http://www.flickr.com/photos/anamarialeon/5698557334/>  
<http://arts.mit.edu/fast/fast-light/meejin-yoon-light-drift/>

### *Cloud*

<http://www.smigla-bobinski.com/newsletter/ADA-Moscov.html>  
<https://ca.news.yahoo.com/photos/canadian-artists-stunning-cloud-installation-slideshow/>

### *Umbrella Project*

<http://arts.mit.edu/blog/uncategorized/up-the-umbrella-project-2/>  
<http://blog.pilobolus.org/2013/05/up-at-mit/>

### *Miscellaneous Inspiration*

<http://www.vancitybuzz.com/2014/03/ted-conference-aerial-sculpture-unveiled-colours-change-waving-mobile-devices-photos/>  
<http://arts.mit.edu/fast/fast-light/lightbridge/>  
<http://aaron-sherwood.com/works/firewall/>  
<http://dailywhatnot.com/aaron-sherwood-and-mike-allison-firewall/>

## Thank You

Hunter Guarino - for lending me the box frames  
Steve Levine - for helping with transmitter firmware code  
Kent Barrett - for a wonderful semester in 21M.734