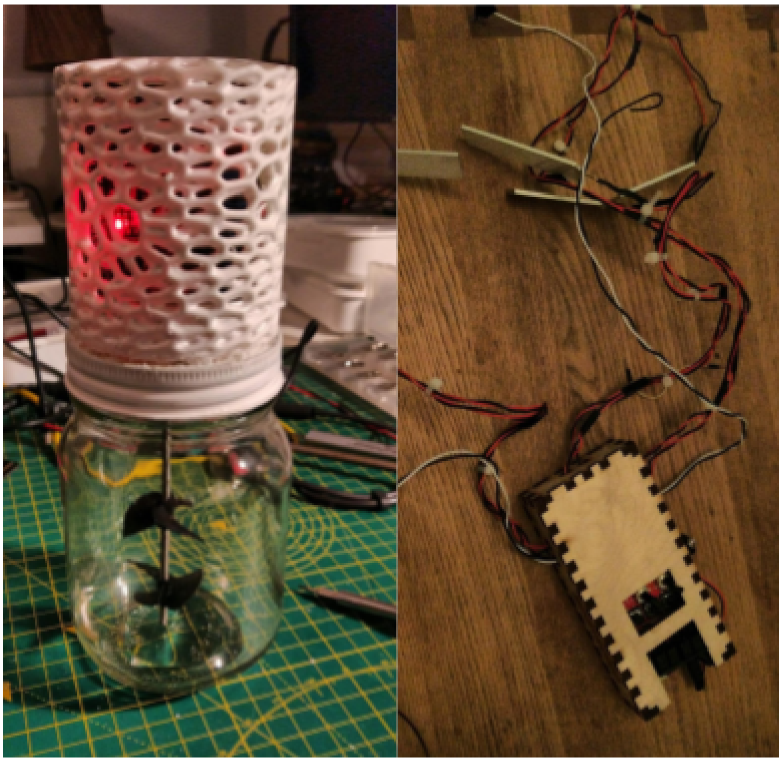
Project Lightbloom

A creative exploration of artificial and biological light.



ABSTRACT

A journey into a creative project aiming to “illustrate a dichotomy between artificial and “natural” light sources, inspire intrigue and wonder into marine biology and explore the human relationship with light” with an unique AV experience using two easily deployable and portable light machines/systems, one using the agitation through hydrodynamic shear stress of bioluminescent dinoflagellate algae and one using the activation of white, fluorescent LED panels. The project yielding mixed results in achieving the design brief. Succeeding in creating two systems usable in a musical performance and aesthetically suitable but failing to implement the automatic algorithmic audio control of the systems using DSP.

CONTENT

- Life that Glows - An inspiration and Literary review as an overview of the overarching research done into the aesthetics and philosophy around Lightbloom and its creative output.
- The Machines of Light - A look into the final (or planned) builds of the Lightbloom devices, Wocobida and Nostromo and the design choices around them.
- A Year of Light and Darkness - A chronological view of the build process and the challenges I faced with a more conversational tone.
- The Past and Future - An evaluation of what I created, the success and failures and the future of Lightbloom.

BEVIS HALSEY-PERRY 33355024, CREATIVE COMPUTING YEAR 1 2017, CREATIVE PROJECT RESIT

Life that glows

A lot of the inspiration and things discovered were documented and co-wrote in a blog https://lightbloomblog.wordpress.com with my friend Doug on the music sections and me on the rest. Some of It is reiterated and reworded better here.

A collaboration

A musician and an creative technologist:

From the very beginning of this project, I have shared a vision with a good friend , former flatmate and inspired 3rd year pop music student, Douglas Pisterman. I knew that if I was to undertake such an ambitious project I would need artistic inspiration and friendly motivation. It was decided we would research together but create separately, a common philosophy and aesthetic vision but with my creations built to his needs to give my design focus and purpose without losing my creative input. A purpose that would have meaning in the form of his final year performance at The Albany. The pressure was on, and Lightbloom was born.

Biology

David Attenborough - Life that Glows

This documentary started it all. Watching it last July in a smokey room, finding that making light, luminescence, wasn't restricted to a fusion reactor in the sky or complex human invention, made imaginations run wild. With Attenboroughs soothing voice in the background me and my musician friend Douglan Pisterman had a bright idea that maybe Bioluminesence could be harnessed to create a biological lightshow.

Bioluminesence

Bioluminescence is a biological process which occurs from chemical reactions producing light in living organisms. The most spread example on land would be fireflies or glow worms. This species uses bioluminescence to alert a mate for reproduction or to dazzle predators with light.
However, the main playground for bioluminescent activities is situated within our oceans and takes many diverse forms. We see a similar use of bioluminescence than in the land species. Bioluminescence is used as a predator safe keeper or as a counter attack. But it is also the major communication mechanism in the deep sea where the sunlight doesn't penetrate under the thick volume of salt water. It is produced by the oxidation of a light-emitting molecule, generally called luciferin,in conjunction with a catalyzing enzyme (luciferase or photoprotein).For lightbloom the study was focused on dinoflagellates (Dinos), a marine algae which alternates between photosynthesis and luminescence on a circadian basis. Similar to the human beings, the algae has an active cycle during the day and a sleep pattern at night. At night it emits light as to repeal its predators. It is also known to be highly toxic and capable of engulfing microscopic fish eggs.

Dinoflagellate Culturing and Physiology

Most of the research into Dinos bioluminescent response came from a very well researched paper[1] from the Journal of Experimental Biology. The paper found used an obstruction in the cells hydrodynamic flow to initiate a bioluminescent response and found that the average response latency was between 15-22ms and could create multiple flashes with a short interval of 5ms. The paper also suggests that the bioluminescent response is an evolved “rapid anti-predation behavior”

I was briefed about culturing first from previous attempts at the London BioHackspace but followed it up further. The best resource was CCAP’s own info sheet[2] which explained how to create culture medium from artificial seawater and an algal medium, suggested to be L/1 but I choose F/2 as it was already available at the biolab. The algal medium contains all the necessary minerals, salts and metals needed for healthy algae growth.

Philosophy and Psychology

Biophilia

The term Biophilia can be translated as a love for living biological systems by Edward O. Wilson, a biologist who created the branch of sociobiology presented this theory in his book Biophilia (1984). This hypothesis suggests that humans have an innate sense of curiosity towards living organisms that surrounds and eludes them As much as I believe in an innate sense of the human specie to connect with nature. Which would probably be intensified in our early evolutionary traits subjugated by our instincts and the structural food chain. I feel that humans have closed themselves in their own technological, concrete environment.

The main reason of my skepticism is a study by NOAA concerning the percentage of known marine surface by humans. It is revealed that to date we have explored approximately less than five percents of our ocean therefore we only know a fraction of the biological life which exists in our planet. This data would go against Wilson’s theory as the ocean is the primordial element of life on our planet and yet, humans have preferred to spend more budget on space exploration in which no living organism has been found to this day.I believe this is a legitimate motive for the use of bioluminescence in the performance as showcasing one of the most visually striking phenomenon of marine biology. This would give me the opportunity to reflect on our relation to different sources of light and to reconnect the audience with nature through the use of biological performance.

Humans response to light

Kind of Blue:

As the bioluminescent properties of dinoflagellates is a relatively recent discovery, there isn’t much research regarding human physical reaction, if there is any, to its light source. We know that they are highly toxic for some marine life and humans if eaten in large amounts. In order to legitimate the relevance of using bioluminescent algae in the project I shall reflect on humans relation to blue light and how it would fit into the final performance.

Exposure to artificial light can be damageable for the human circadian cycles which forces the body to secrete melanin (responsible for Breast Cancer in some cases). In order to counter act these unwanted effects, the professor George C.Brainard and his colleagues tested 72 healthy women and men to determine the strongest wavelength to disrupt melatonin secretions. The blue wavelengths has been proven to be beneficial to the restoration of the circadian cycle. As well as

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regulating our sleep cycles, blue light has been proven to influence the left brain hemisphere and to develop memory. In addition to these reactions, Steven Lockley has added that the subjects of the Brainard experiment had a quicker, more acute auditory reaction time and fewer las of attention under blue light. These results correlates with the aim of the second part of the performance as, the blue light that Pyrocystis Lunula emits will create a sense of focus on the musical aspect of the piece. This will be a good way to express the dichotomy of human's reaction to different sources of light as the unfocused, dizziness feeling provoked by the first part of the performance will be opposed to the acute, calming properties of the blue light.

Artificial Sleep:

We call “artificial”, a man-made mean or object often used to mimic natural phenomenons. In order to have visibility on our surroundings when sunlight isn’t available, man surrounded itself with artificial sources of light. Whether it is to illuminate our habitations, read a book or to simply decorate our rooms, artificial lights have a particular place in human activities.
We can divide artificial light sources in two types, Incandescent and Luminescent
According to Dr. Habil Andras Majoros, incandescent lamps produce light by the radiation of a filament at a high temperature. He ranges in this category, filament incandescent lamps and tungsten halogen lamps.
Luminescent lamps are quite different as exciting electrons generate the light they produce.In this category he ranges fluorescent lamps, mercury lamps, metal halide lamps and high-pressure sodium lamps. I chose to focus on fluorescent lamps (LEDS), as I believe the bright white light of LEDs could be a quite direct expression of the effect of artificial light on the human body.

Studys:

1) The Stefania Follini experiment[3]
Stefania Follini is an italian designer, who decided to conduct an experiment regarding the reaction of a human being in an enclosed space for a prolonged period of time. On January 13th 1989, the 27 year old woman came to live in a cave created 9 meters below the surface of New Mexico, USA. She would remain there until May 23rd, 1989, 130 days later. She had no way to know the time as she didn’t possess a watch and was kept away from natural light cycles. As she came out of the cave she couldn’t believe that it was May 1989. According to the experiment, the number of days that actually passed was 70 days more that the number perceived by the person in the cave. The absence of natural light on this subject provoked an increase of hours in the perceived day. This unbalance in the normal circadian cycle (12 hours of daylight, 12 hours of obscurity)can create a jet-lag effect due to reduced sleep cycles.

2) The Royal Commission on Environmental Pollution report
According to the british Royal Commission on Environmental Pollution, humans living in urban environments should be doubtful about the common use of artificial light. Light is one of most active agents interacting with biological systems. If artificial and constantly used, It can disrupt their sleep cycles, or help stimulate hormone production. The reports indicates that a constant exposition of artificial lighting on migrating animals can have devastating effects. The reduction of obscurity and the heavy constant stimulation can disrupt their reproduction cycles,in the case of birds, as well as their eating habits, as it is the case for bats.In contrast, constant artificial lighting exposure at night on humans have been associated with inhibiting production of melatonin.The inhibition of melatonin in known to be associated with the incidence of certain breast cancers. Which correlates with results found in human beings working on regular night shifts.The reports correlates with the findings of Stefania Follini’s experiment in that sense, as it gives us a reason to believe that the disruption of sleep cycles induced by artificial lighting in human beings, can be very detrimental to a normal biological body. In addition to this biological reaction, the report argues that the disappearance of our relation to night lights (stars, astral bodies) creates an increased sense of spatial confusion. To put in context these findings, the commission uses The

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Bortle scale.This scale measures the darkness of the night. To give a point of reference, a remote desert with no artificial lights ranks as a one whereas London ranks at a nine.

Two aspects of artificial light's effect on humans interests me, the disruption of sleep cycles through intensive artificial light exposure which creates in turn a mental disruption. And, the overgrowing sense of spatial confusion within our environments which is also caused by continuous artificial light disruptions.

Art & Music

Erika Blumenfeld

Erika Blumenfeld photographed the agitation of bioluminescent dinoflagellates to create ethereal wispy pictures of bright blue algaes across a black background with the aim to "activate a dialogue about our natural environment and our relationship to it.". She did this by "By working with a low concentration of organisms and a slow flow rate, the artist was able to produce single flash events, which depicts the luminous expression of individual organisms.". And also created a video with high concentrations to depict the "turbulent flow field in motion" that reflect the natural turbulence of the ocean. This piece was a primary inspiration, both something that proved it could be done and that artists were already interested in the visual impact such a piece could have on raising the awareness of ecology.

Kaityn Aurelia Smith

I was made aware of Aurelia Smith by the collaborating artist Doug, he used her as inspiration to create the Lightbloom music tracks (See Performance section) What he had to say about her was that her use of "arppegiated synth lines live on their own, the randomness and Smith's expression on the cut off filter create a sense of flashing lights in a natural environment."

Ryoji Ikeda

Another inspiration of Dougs was that of Ikeda. Especially his work with bright LED panels and his early work with group 'Dumb Type', which went on to inspire me to create Nostromo as the Artifical light part of Lightbloom. What Doug said of Ikeda was "These performance are a combination of electronically ambient sound with excessive light activities which creates a hyper photosensitivity in the audience's perception. ". This was exactly what I wanted as a juxtaposition to Lightbloom. Ikeda depicts an eery environment functioning similarly to natural patterns but internalized by our human technologies, this would be the foundation of Nostromo.

Alien (Film):

A film I hold so dearly I have a signed copy of making of book by the vfx artists, Alien played a pivotal role in the creation of the Nostromo system, so named after the films ship. The dirty cyperpunk-esqe dystopian future of the Nostromo with its 80s electronics echo the artificiality of the light I wanted to create. MU-TH-ER the ships computer (Pictured Right) was the inspiration to use LED backlights with their soft uniform glow and clean aesthetic. The films interplay between human creation, the Nostromo and the Alien, the xenomorph also plays directly into the ideas I wanted to convey.

Conclusion Points

- Bioluminescence in dinoflagellates is complex and incredible but quite well researched and documented
- Dinoflagellate response rate and interval is very short and therefore could be used as an audiovisual medium.
- The relationship of humans and the oceans is an increasingly developing one where it is one of the only frontiers of spacial discovery left despite it being such a fundamental part of our natural history.
- Humans response to different wavelengths light is profound and can have severe mental effects both in spatial perception and sleep

Design Brief

Design, Prototype and Fabricate two easily deployable and portable light machines/systems, one using the agitation through hydrodynamic sheer stress of bioluminescent dinoflagellate algae and one using the activation of white, fluorescent LED panels. These light machines are to be triggered programmatically or algorithmically by an audio input using DSP techniques. With the goal to illustrate a dichotomy between artificial and “natural” light sources, inspire intrigue and wonder into marine biology and explore the human relationship with light through an exotic AV experience.

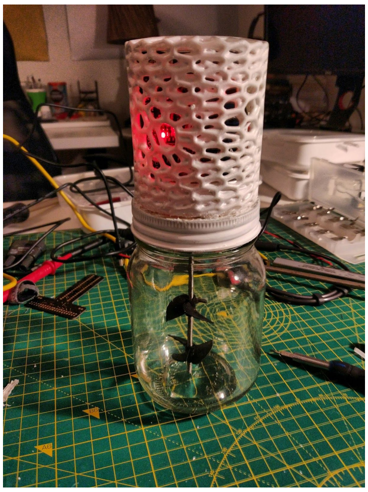
The machines of Light

As the above inspiration talks about, it was important to create a juxtaposition, as this reflected the artist's desire and reflected the philosophy of the project. So two light machines were created. One focused on biological luminescence (Wocobida) and the other artificial incandescence. (Nostromo).

Wocobida

(Wireless Osc COntrolled BIoluminesent Dinoflaggulate Agitator)

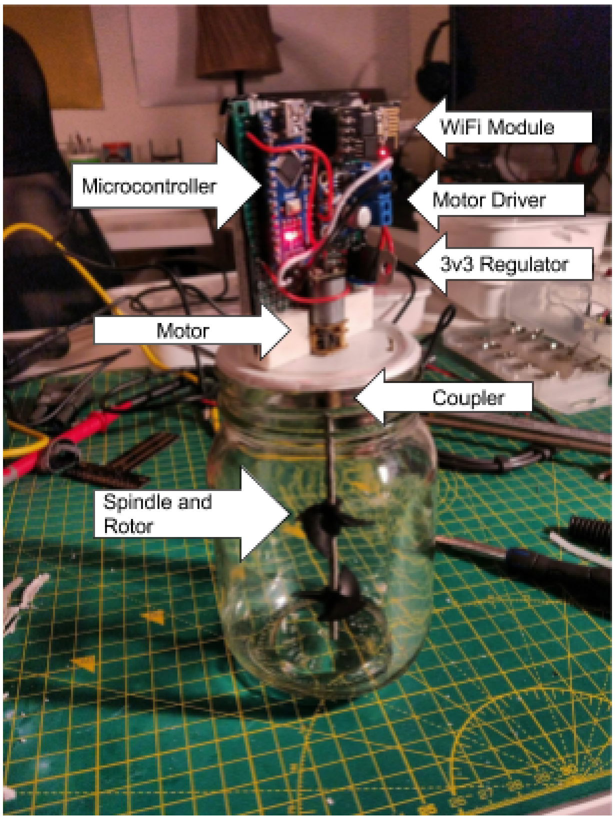
The Design



The overall design aesthetic of the Wocobida system was a biotechnical one. I wanted to create a balance of electrical hardware and organic lines while maximising the effectiveness of the bioluminescence. I settled on a design (pictured left) where the algae would not be obstructed by placing in a large glass jar, viewable from a 360 angle. I found that a mason jar was the best choice, as the centre of the lid was not fixed but held down by the collar, meaning that the hardware could be fitted to the lid and removed easily from the rest of the jar by just unscrewing the collar. This meant the hardware (explained below) could be isolated from the liquid below. The cover was attached to the collar and was designed in Autodesk 360 with help from a design student. The cover was designed to reflect marine life by taking inspiration from coral formations. I let the cover have holes in so when the system was viewed, small glimpses of the internal hardware could be viewed adding to the bio-cyberpunk feel I was after, even leaving the microcontrollers LED's to shine through.

The Hardware: Wocobida Node

The envisioned final hardware (Pictured Right) consisted of 5 sub-systems:



- **Microcontroller:**
  I first had played with the idea of just using the ESP-01 wifi board (explained later) and prototyped using an Arduino MKR1000 (A combination of an M0 processor and an ESP8266) but settled on having a dedicated microcontroller. I chose a Arduino micro clone that uses the Atmel328P at 3v3 volt logic. I chose this for the following:
  1. It is cheap and reliable. Only costing $3 each from china. The 328P is very reliable with a mature community. I knew I was going to break a few. (5 in total!)
  2. Plenty powerful for my needs, 20Mhz and 32kB of memory left lots of room for added computation as was not going to do any DSP on this board.
  3. 26 I/O pins left lots of room for adding sensors in the future. The primary reason I didn't use just the ESP-01, even though the ESP did have one PWM channel I could have used for motor speed control.
  4. It runs Arduino out of the box.
  5. 3v3 logic was what the ESP-01 and the Motor driver used, eliminating the need for a logic converter

    6. It was 9v tolerant for power.

- **WiFi breakout board:**
  The ESP-01 is a Wi-Fi module with a fully fledged SoC (system on a chip) and full TCP/IP stack by Expressif systems. The ESP-01 that can act like a microcontroller itself so I first considered using just the ESP-01 but found that it both lacked power and only 1 I/O pin that could be chained to 6 that restricted upgrades in the future. I chose it for the following:
    1. It is very cheap, only costing $1.5 each and I already had a surplus from a previous project (Anvil Hack 2, WiFi Anvils).
    2. Can be controlled by AT-commands on bare-metal without having to flash firmware.
    3. Very small, could fit on the protoboard without much issue.

  There were a few major downsides that I later learned. Firstly the board is very sensitive to power requirements. The board would fail entirely if it was not supplied with enough current, creating the need for a power supply circuit, it could draw up to 2.5A of current when trying to establish connections! Secondly, the GPIO pins, even at slow baud rates of 9600 would be very noisy, sometimes getting completely garbled information on the serial port even when the Tx was pulled down with a resistor.

- **Power Supply:**
  The power requirements of the ESP-01 and the desire to power the system with a small and cheap 9v rechargeable battery necessitated the need for a voltage regulator. The 9V battery could directly power the arduino but I used a 3v3 voltage regulator to power the ESP-01 and Motor Driver at a regular current and voltage.

- **Motor and motor driver:**
  I chose the 50:1 micromotor from Pimoroni as the motor that would drive the agitator. Chosen because its stall torque was 0.5kg.cm far less than the viscosity of water and could spin at said torque at 420rpm, enough to create the turbulence needed. Its size was also incredibly advantageous to being able to fit it within the system and even mount it on the protoboard.
  The motor driver is Adafruits DRV8871 H-Bridge DC board. Primarily used because of its small form factor with included mini-terminals and protection circuits.

- **Agitator: Spindle and rotors:**
  This was a hard thing to source, but was on the list from the beginning. To extend the motors drive shaft I used a 2.5mm coupler and 2.5mm steel rods commonly found in RC Hobby shops. I used 2 RC board propellers as rotors that would create the turbulence and shear stress in the water for the algae to activate. I inverted them to face each other so that the thrust from each would meet and create increased turbulence.

The Software: Wocobida Node

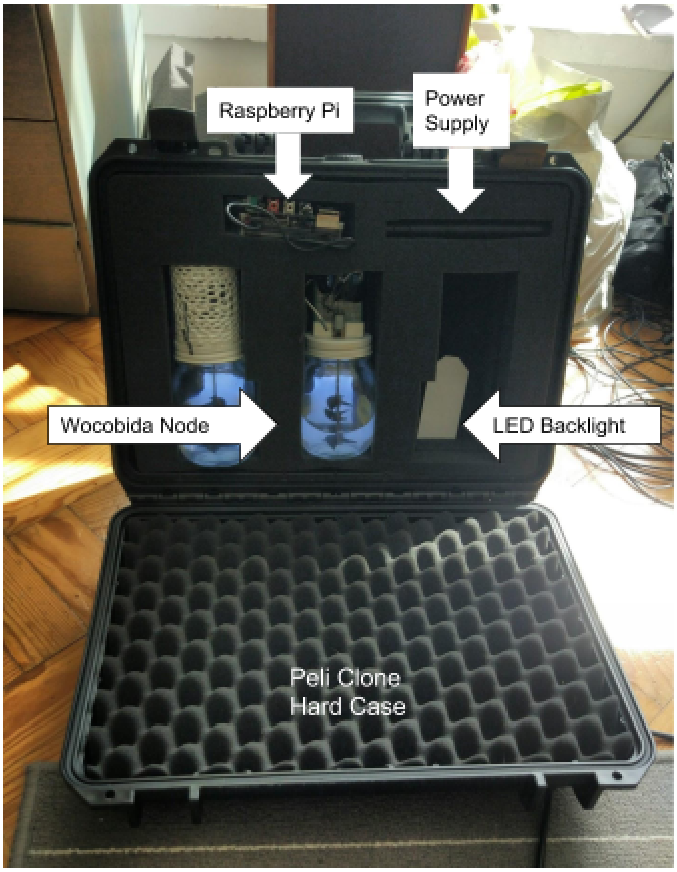
This was the biggest failure of the project so I will outline what I did achieve and then in italics what I would of added..

SEE INDEX FIG 1 this is my prototype code used to attempt to connect the arduino to the ESP-01. It works as follows.

- It first sets up the necessary Arduino libraries. I'm using the Software serial library as the hardware serial pins are being used to interface with the arduino and debug it via USB. I generally do this unless I don't need access to the arduino. I'm also using the ESP8266 library that abstracts away the AT-commands used to interface with an ESP based chip into a user freindly API
- It then defines the pins being used for the software serial connection and instantiates a ESP8266 object called esp01.
- Then we define some global variables for input, test and timing.

- In the setup function we attempt a connection to the AP
    - First we define some baud rates and locals
    - Set the IP protocol to TCP
    - Set the transmission format
    - Turn on the ESP-01 wireless
    - Reset it from any connections it may of had priot
    - Connect to AP (in this case an AP on my phone)
    - Check if its successful
    - If so set connection to multiple IP connections allowed (not really necessary but useful)
    - Connect it to TCP/IP server on my phone
    - If i'ts connected send confirmation to serial connection.
- In the main loop which is operating as fast as the ATmega826p allows, I could use a library like 'narcoleptic' to enforce a sleep mode and save battery when connection is idle.
    - we have first check if the esp01 is actually on
    - Then a serial input check to test for input into the serial.
    - We ping from the esp01 to test the connection every 10s
    - Then we listen for any incoming messages, if there is none after 5000ms it will restart.
    - If there is a message from the server print a confirmation to the console
    - *This is where I would check that message for a motor=ON command and act accordingly*
    - Echo that message back
- At the bottom we find a function that is used, to read the serial input and check for newlines. This was taken from arduino examples.

The Hardware: Wocobida Base



Because the project necessitated that I had to keep a living substance alive during transportation I designed a base station for the following:

- **Homeostatis** the Wocobida base station has LED backlights that are controlled by the GPIO pins on the Raspberry Pi and triggered in a 24hr Light and Dark cycle using a simple Cron job to maintain the algues circadian rhythm in transport. Also it was necessary to be able to change the circadian rhythm so that it was in a night cycle when it was needed, so I began but did not complete a shell script that would slowly change the cycle over a week period.
- **Control** the base station would also work as a hub that would control the Wocobida Nodes. An audio shield,[4] the audio injector rpi hat,was used to give the RPi advanced audio capabilities. I chose the audio injector because it was cheap and had low jitter operation with 32 bit operation, plenty powerful for the DSP I wanted to do. It also used stereo RCA so to give the musician a ubiquitous input, although I planned to use a RCA to jack adapter for ease of use.

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The Software: Wocobida Base

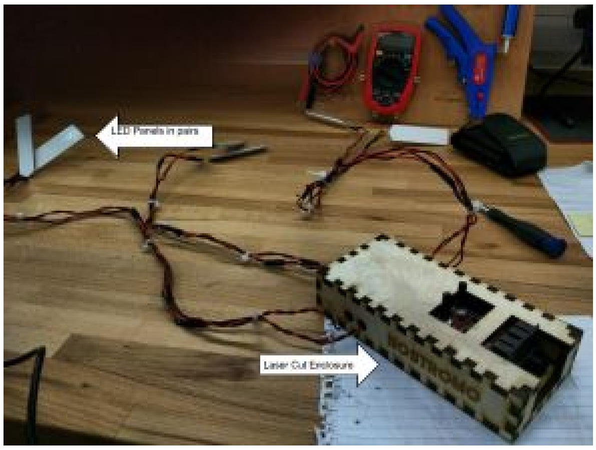
The only thing that was implemented here in the final build was a simple cron script job that turned the LED panels connected to the Pi on and off at the right time to keep the algae in its circadian rhythm.

What I intended and planned was as follows:
- A simple python program as middleware that takes the input of the low latency audio hat and pipes it into
- A local node.js server with meyda[5] that would detect the RMS of the audio input.
- If over a set threshold it would trigger a TCP message to a corresponding Wocobida node.

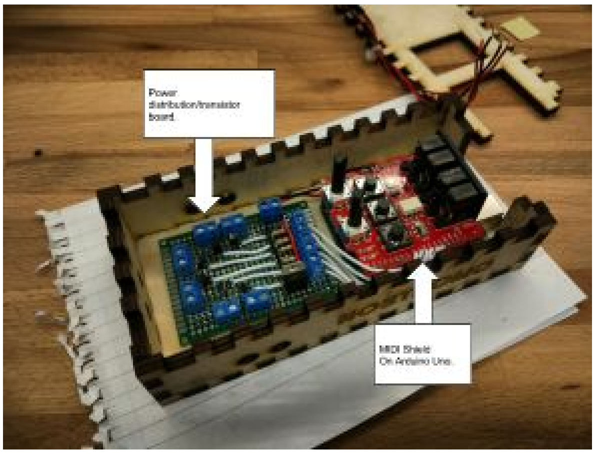
Nostromo

The Design

Nostromo was designed to be aesthetically clean and very functional. I left the LED panels loose so that the artist could place them in anyway depending on the performance. I maxed out the available pins on the Arduino to allow for 6 LED panels. I used fairly small panels so they could be placed around a synth or laptop setup without it being obtrusive. I grouped the panels into two to reduces the unwieldy nature of it in transport and setup.



The Hardware



The final design of Nostromo (Pictured left) consisted of 3 Sub-Systems:
- **Microcontroller:**
  I used an Arduino Uno for simplicity and that I could easily add MIDI capabilities via a shield.
- **MIDI Shield[6]:**
  I used the Sparkfun MIDI shield because it has a mature community, MIDI DIN pins and can work as a MIDI slave without reflashing the USB firmware chip on the UNO
- **Transistor board:**

I needed the LED panels to be powered independent to the Arduino as the GPIO pins on the Uno doesnt give enough current so I created a transistor board where the base of each transistor, I used a basic NPN trasistor, is connected to the I/O pins and power is provided by a 3v3 voltage regulator connected the Vin of the Uno. I used Terminals for the LED panels because I was worried one could be pulled and I didn't want to put stress on a solder joint that could damage the circuit.

The Software

LOOK AT FIG 2 (explanation not needed, is in comments)

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[5] https://github.com/meyda/meyda
[6]

Build Timeline

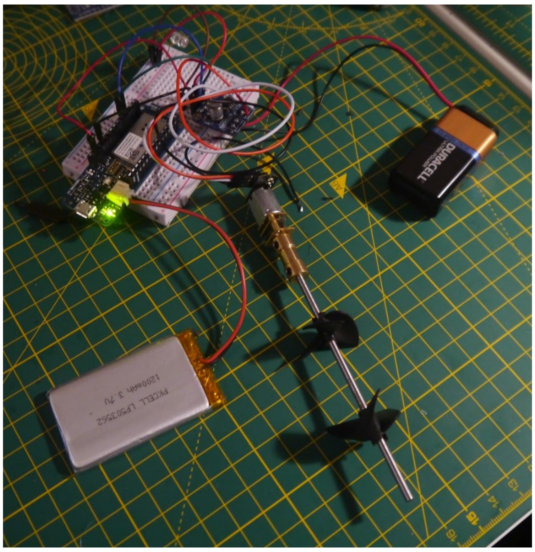
Research

Apart from reading a few academic papers, articles and websites and a brief encounter with bioluminescent algae in the red sea; I had no interaction with it. So the first thing I did was find a biological laboratory I could experiment and culture them. Fortunately London has a public co-op funded Class 1 Biolab in the basement of the london Hackspace in Hoxton. I went for an induction and was taught health and safety and the basic operation of the autoclave and pipettes. I found that a few people had experimented with Dinoflagellates[7], cutely named “Dinos” in the biohack community, I talked with them on the Slack channel and gathered some advice on culturing.

Because the biolab is considered an educational institute I could purchase “Pyrocystis Luluna” starter cultures from CCAP[8] and along with the research I did I created Artificial seawater and F/2 algue medium as a culturing medium. After a fewdays of culturing I came back and tested the culture. After a few shakes in total darkness I could see flashes of a blue/green as an ethereal light swirling in the liquid. It was no light I had ever seen before. I tried to photograph it both using a Lumix G and my Phone but both failed to capture the light. I put it down to poor light sensitivity of the camera sensors for such a short lived and dim light source. The light was also dimmer than I had seen on other videos. I concluded that it had not cultured long enough.

Prototyping

For the first prototype I wanted to reduce the number of components and complexity and just test the function of the motor over wifi.
Fortunately I had just acquired an Arduino MKR1000 from volunteering at BET with arduino. This is an IoT dev platform that contained an M0 processor combined with a ESP8266 (a more featured version of the ESP-01) and a LiPo power supply, so it contained all the components needed in the final build but far more expensive at £35. I used this with the code explained above form the final build and it worked without a hitch! Success!



Initial Wocobida Build

As soon as I had acquired the parts I threw myself into soldering on headers (see right top) and breadboarding the circuit without the

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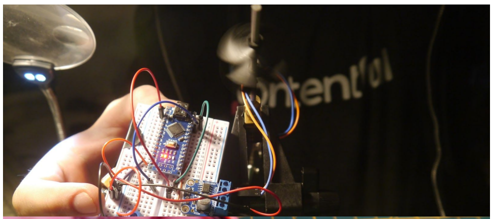
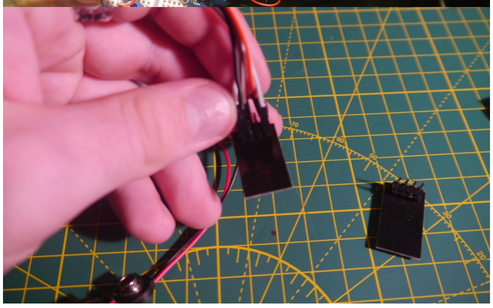
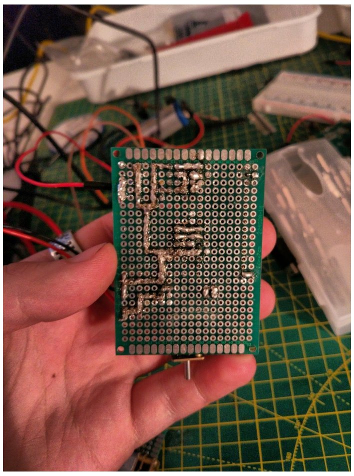
wifi subsystem. I foolishly didn't create a circuit diagram, something I reflect on in the evaluation. The circuit without the wifi worked fantastically though. (see right mid).

One very annoying thing when I began to start integrating the ESP-01 was that it is impossible to place it on a normal breadboard as its pins were configured as a 2*3 block, meaning on a horizontally connected breadboard, the pins would just short themselves. This lead to some very annoying use of long jumper cables. (see right bottom)



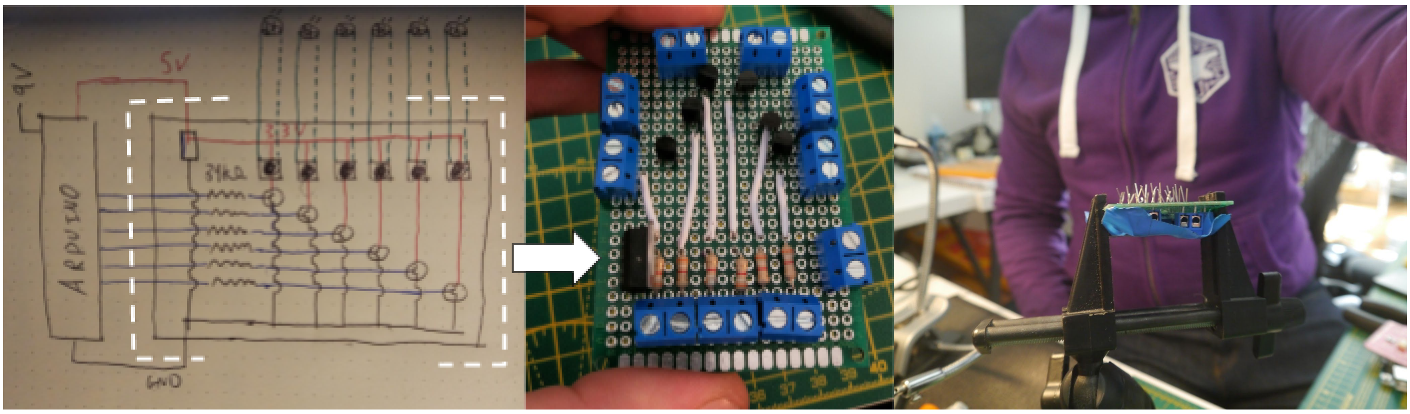




Once I had the wifi subsystem breadboarded and kind of working, I jumped straight in putting it all on protoboard, a decision I would regret massively later. I chose to use drag soldering to create connections between the boards (see left) instead of lots of jumper wires. Both because I had the tools (flat solder tip, flux pen and a good solder sucker) and a challenge to myself. I think it ended up well; with a tidy safe saving board with, from my testing, no defects.

Nostromo Build

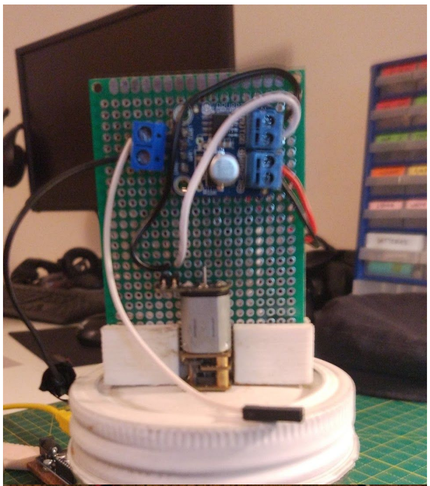
The build of the Nostromo was a far different build. Firstly the build was very quick. This is because Doug needed it very quickly, within a 2 week period for a gig. So I quickly sourced the parts, hence the relatively simple components compared to Wocobida. I knew I only had one shot to get it right so I created a circuit diagram this time for the transistor board, especially as I had to do some calculations for the base resistors and I had to fit it within a fairly small board (see bottom). I spent quite a few hours on how I would lay out the components on the board to reduce the complexity of the soldering and use of jumpers. I found a very effective v-shape for the transistors that allowed me to put the LED connectors in a half circle. One I had fabricated the board I found I realised I couldn't place it on top of the MIDI shield without removing the MIDI shields buttons, which I wanted to be able to map to brightness and manual control. So I designed an enclosure in Fusion 360 that would place it next to it (see 'Machines of Light' section) which I then laser cut out of 4mm ply on the Hatchlab laser cutter.

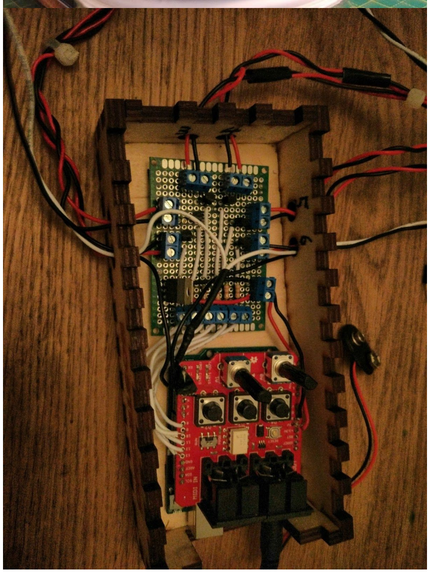


Emergency Build and Culture

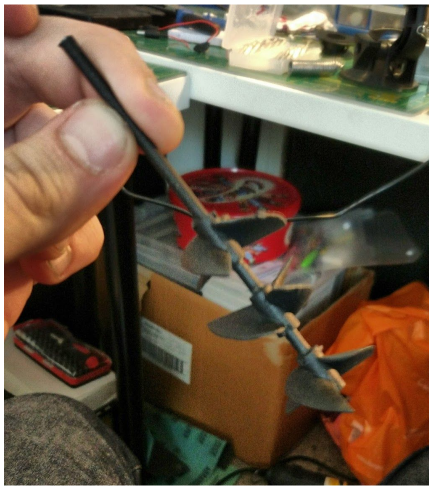
It had come to a week before the performance at the Albany.
I had fabricated two Wocobida node boards (See right top) but without the WiFI subsystem a month prior but had fallen ill for a few months. I had to to pull together and get something to work. I adding the wifi subsystem and started testing. Things were not

going well. Whenever I tried to interface with the software serial the ESP-01 was on I was getting a garbled signal in the console, about 60% random characters. This was not good, without a clean signal, the ESP-01 couldnt connect to wifi and the Arduino wouldn't have a WiFi connection. My goal of connecting them via OSC on WiFi was fading. I spent 2 long nights testing many things. Was the ESP-01 not getting enough power. Nope, it was drawing 2A's at 3v3. Were the solder connections bad. Nope, testing the resistance through them on a multimeter was yielding a good result. Was the Tx line of the serial on a floating ground. Yes! I added a 1Kohm pull down resistor. The signal was better, about 20% random characters on the serial console, but still not good enough for it to initiate a TCP/IP connection. It was a night before the performance, even if I had time to fix it, I didnt have enough time to implement the OSC connection.





I "pivoted" as they say at hackathons. I knew Doug already wanted it to be controlled by a MIDI CC signal, just like the Nostromo, so it could be easily triggered by Ableton. I stripped down the Wocobida Node board down to the bare minimum, just the motor subsystem and battery (see left top). I still needed to be able to control it. I looked back at the Nostromo and realised there was no more digital pins left on the Arduino Uno to be used to control the motor driver. Fortunately, the MIDI board had 3 buttons that were using the rest of the digital pins. So I bypassed them and hijacked those digital pins. I now had 3 digital I/O pins to play with. I added 2 more MIDI CC mappings to the Nostromo and wired them in (see left bottom, the black and white wires). It worked!



I had noticed from previous experimentation that the spindle was rusting very quickly from being submerged in saltwater. I was concerned that the Iron oxide could damage the algae. My solution was to spray the spindle and rotors with plastidip, a spray coating of rubber that was designed to insulate and protect. It has the desired effect and also made it look far better (see right bottom).
I also added a 3rd rotor to add even more turbulence, just incase and to improve the agitation and therefore lighting in the face of potential ambient light during the performance.

A 2 weeks before the performance I had purchased another batch of Pyrocystic Luluna starter culture. But this time asked CCAP to add the medium and culture it themselves for as long as possible. I received nearly a litre of Dinoflagulatte solution a week later and immediately put them in sterilised erlenmeyer flasks with gause on top of the flasks to allow them to breath (see right). I put them in the culturing cupboard at the biolab I had made that consisted of a reflective box with LED lights (used because they produce a more even spectrum of light than incandescent and do not produce as much heat) connected to a simple greenhouse light timer set to be on between 0500-1700 and off between 1700-0500, giving an optimum time for bioluminescence between 1800-2200. Perfect for the performance.

The Performance



This was what it was all leading up to the Pop Music degree pop show[9], class of 2015. Dougs final university performance as his new ego Tartell and my chance to show off what I had been building. He had produced two tracks specifically for the lightbloom project, using the aesthetic we had theorised and how we had both approached that.

https://soundcloud.com/tartellmusic/lightbloom/s-9ltHh
https://soundcloud.com/tartellmusic/lightbloom-ii/s-qNSF1
(NOTE: both tracks will be disabled on 21/08/2017 PLEASE DO NOT DISTRIBUTE OR SHARE)

These are the instrumental versions. The first drawing on artificial light, what was embodied in Nostromo, with its harsh quick bleeps and squeaky tones. And the second filled with bubbly noises and crackling crashing synths meant to invoke oceanic depths and eerie bioluminescence. The different light systems were activated for their respective songs

On the night I came early to the set up and sound check to test the systems were working. I had to find a suitable stand as I found Dougs instrument desk was smaller than initial thought, so I snuck into the store room and round a suitable rugged prop box.

The performance went well and the lights and motors activated at the correct times. You can find a few clips of Nostromo activating here:
https://goo.gl/photos/ZbvF2TSkGwTQTzgv9
And a long one of Wocobida activating here:
https://goo.gl/photos/4cnrdecnbcU7nNMm6
This is where the most disappointment came from. In the clip of Wocobida activating to music, the bioluminescence isn't visible in the slightest, despite asking for the stage lights to be dimmed to nothing. The ambient light totally overpowered the very subtle glow of the bioluminescence.

Here is the ONLY clip where I could film the algae activating in the Wocobida node. Justaposed with Nostromo. Filmed with the initial build complete without the wifi subsytem.
https://goo.gl/photos/VUaAXkT2tm4itFFdA

The Past and Future

Since the beginning of the Lightbloom project it has been riddled with the consequences of my ongoing battle with mental health. Its success and failures have mirrored what has happened in my life. I put my heart into this project but it wasn't always beating.

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Disappointments and Failures

- Did not implement OSC communication.
- Did not implement automatic algorithmic activation to audio through DSP into the Wocobida base.
- Did not push my coding ability as much as I wanted it to. I didnt get to develop the code on the Wocobida node beyond prototyping and the DSP system on the RPi. This is the biggest failure. Not from ability, but fear that I couldn't achieve what I wanted.
- Numerous times the algae culture failed and died. Once from a lighting failure and second from anxiety stopping me tending to them.
- Failed to use the footage taken throughout the project's progress and create a short movie.
- Failed to create what was intended for the performance.
- Did not fully achieve my vision for the final product in the time given. Down to poor time management, planning and lack of mental health coping mechanisms.
- Missed numerous Academic deadlines due to sheer panic, anxiety and depression putting my academic future on the line even with this submission.
- Bad financial planning meant I didn't have access to the components I needed at the right time.
- Lack of primary research into the dinoflagellate algae.

Successes and things learned

- Successfully produced a half-effective lightshow for a musical performance. Despite being disappointed by the failure of Wocobida to be effective during the performance I did successfully create my first hardware that worked in a professional setting.
- Successfully created an aesthetic based on scientific and artistic research and implement them into a design.
- Collaborated successfully on a mix media project with no loss of control over my role.
- Successfully completed a design brief to over 70% of the specification.
- Pushed my hardware design and electronic skills to the limit. Learning much in the process about complex soldering, firmwares, requirements and complex circuit design.
- Created intrigue and wonder as an added layer to a musician's performance.
- Learned how OSC and MIDI works both in hardware and software.
- Learned how the ESP platform of wifi boards works from bare-metal AT commands to flashing firmware and the limitations and quirks of the hardware.
- Learned to successfully prototype but also the importance of creating circuit diagrams and to thoroughly test circuit designs before moving onto protoboard.
- Learned how biolabs function (pipettes, autoclaves .etc), how to culture algae and the biology of bioluminescence.
- USE HEADERS! Unsoldering the 16 pins on an arduino when they inevitably blow is a time waste, use headers to easily swap out components
- Learned to be ambitious, because I can generally achieve the things set out BUT to consider my mental health in how hard I can actually work towards that ambition.
- I must plan more before approaching a project of this magnitude. Taking my limitations into consider I should create soft-deadlines through-out the project to stay on track and allow for time off in case of illness.
- Do not fear your own project. The scale of the project created mental blocks of anxiety and fear that stopped me working on it when I needed to.

Ambitions and Hope

- To continue the project. Completing and refining Wocobida and adding a few more light systems to the project. A large moon shaped version of Nostromo is in planning.

- Wocobida Nodes; Revert back to initial design and successfully implement OSC or DMX control over Wifi using the ESP-01, add light and temperature sensors to test the nodes bioluminecence activation within the base and to monitor the temperature to reduce risk of overheating and killing algae.
- Wocobida Base; Add intended automatic audio control to the RPi allowing an audio input to remotely trigger the Nodes, Improve the homeostasis system with fans that can reduce internal temperature and an external system to monitor and control said system. Also add a RTC (Real Time Clock) powered by its own battery incase the power pack loses power, I want to retain the current time.
- To film Wocobida with a live performance from Doug using low-light sensitive cameras to create an original music video.
- Nostromo; to create a more flexible and compact system with a more intelligent and modern control.
- Hope to approach projects in the future with more consistent ambition and not to fear my own success. To find my grit.

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Fig 1

```
#include <SoftwareSerial.h> //used as hardware serial already in use
#include <ESP8266wifi.h> //include the library that abstracts most AT commands away

#define sw_serial_rx_pin 11 //  Connect this pin to TX on the esp01
#define sw_serial_tx_pin 12 //  Connect this pin to RX on the esp01
#define esp8266_reset_pin 5 // Connect this pin to CH_PD on the esp01,

// sets the digital pins being used for the software defined serial interface.
SoftwareSerial swSerial(sw_serial_rx_pin, sw_serial_tx_pin);

// the last parameter sets the local echo option for the ESP01 module.
ESP8266wifi esp01(swSerial, swSerial, esp8266_reset_pin, Serial);

String input;
boolean stringComplete = false;
unsigned long nextPing = 0;

void setup() {
  input.reserve(20);
  swSerial.begin(115200);
  Serial.begin(9600);
  while (!Serial);
  Serial.println("Starting wifi");

  esp01.setTransportToTCP();// this is also default

  esp01.endSendWithNewline(true); // Will end all transmissions with a newline and
carrage return ie println.
```

```
  esp01.begin();

  swSerial.write("AT+CWQAP\r\n"); //disconnects the ESP-01 from any

  esp01.connectToAP("hello","qwerty1234");//an access point created on my phone
 //esp01.connectToAP("BTHub5-6F8R","49675456b6");
  boolean apConnected = esp01.isConnectedToAP();
  if (apConnected == true) {
    Serial.println("connected to wifi");
  }
  swSerial.write("AT+CIPMUX=1\r\n"); //sets the ESP-01 to a multiple IP connection
  esp01.connectToServer("192.168.43.109","8888");
  boolean serverConnected = esp01.isConnectedToServer();
  if (serverConnected == true) {
    Serial.println("connected to server");
    esp01.send(SERVER, "ESP-01 test initiated");
  } else {
    Serial.println("Failed");
  }
}

void loop() {

  //Make sure the esp01 is started..
  if (!esp01.isStarted())
    esp01.begin();

  //Send what you typed in the arduino console to the server
  static char buf[20];
  if (stringComplete) {
    input.toCharArray(buf, sizeof buf);
    esp01.send(SERVER, buf);
    input = "";
    stringComplete = false;
  }

  //Send a pingevery 10 secounds
  if (millis() > nextPing) {
    wifi.send(SERVER, "Pinging, anybody out there!?");
    nextPing = millis() + 10000;
  }

  //Listen for incoming messages and echo back, will wait until a message is
received.
  WifiMessage in = esp01.listenForIncomingMessage(5000);
  if (in.hasData) {
    if (in.channel == SERVER)
      Serial.println("Message from the server:");
    else
      Serial.println("Message a local client:");
    Serial.println(in.message);
    //Echo back;
```

```
    esp01.send(in.channel, "Echo:", false);
    esp01.send(in.channel, in.message);
    nextPing = millis() + 10000;
  }

  //If you want do disconnect from the server
  // esp01.disconnectFromServer();

}

//Listen for serial input from the console
void serialEvent() {
  while (Serial.available()) {
    char inChar = (char)Serial.read();
    input += inChar;
    if (inChar == '\n') {
      stringComplete = true;
    }
  }
}
```

Fig 2

```
#include <MIDI.h>  // Midi library for Arduino
// Just setting up the vars for the led pins
int led1 = 8;
int led2 = 9;
int led3 = 10;
int led4 = 11;
int led5 = 12;
int led6 = 13;
const int LEDInput = 6;             // LED that signals incoming MIDI CC data
const int LEDTester = 7;

MIDI_CREATE_DEFAULT_INSTANCE(); //weird necessary code for the MIDI library

// The whole of setup is just defining all the LED outputs and instantiating to off
void setup() {

  pinMode(led1, OUTPUT);
  pinMode(led2, OUTPUT);
  pinMode(led3, OUTPUT);
  pinMode(led4, OUTPUT);
  pinMode(led5, OUTPUT);
  pinMode(led6, OUTPUT);
  pinMode(LEDInput, OUTPUT);
  pinMode(LEDTester, OUTPUT);
```

```
  digitalWrite(led1, LOW);
  digitalWrite(led2, LOW);
  digitalWrite(led3, LOW);
  digitalWrite(led4, LOW);
  digitalWrite(led5, LOW);
  digitalWrite(led6, LOW);
  digitalWrite(LEDInput, HIGH);     // Sparkfun MIDI sheild LED's are
  digitalWrite(LEDTester, HIGH);    // wired backwards: HIGH = Off.

  MIDI.begin(MIDI_CHANNEL_OMNI);              // Launch MIDI with default options
  MIDI.setHandleControlChange(CCFunction); // Launch MIDI control with callback to
CCFunction

}

void loop() {
  MIDI.read(); //Read the MIDI input as fast as it can
}
// Basically a huge switch case that takes the midi value number and maps
// it to a corresponding led.
void CCFunction(byte channel, byte number, byte value) {
  switch (number) {
    case 21:
      if (value > 1) {
        digitalWrite(led1, HIGH);
      }
      else {
        digitalWrite(led1, LOW);
      }
      break;
    case 22:
      if (value > 1) {
        digitalWrite(led2, HIGH);
      }
      else {
        digitalWrite(led2, LOW);
      };
      break;
    case 23:
      if (value > 1) {
        digitalWrite(led3, HIGH);
      }
      else {
        digitalWrite(led3, LOW);
      }
      break;
    case 24:
      if (value > 1) {
        digitalWrite(led4, HIGH);
      }
      else {
        digitalWrite(led4, LOW);
      }
```

```
      break;
    case 25:
      if (value > 1) {
        digitalWrite(led5, HIGH);
      }
      else {
        digitalWrite(led5, LOW);
      }
      break;
    case 26:
      if (value > 1) {
        digitalWrite(led6, HIGH);
      }
      else {
        digitalWrite(led6, LOW);
      }
      break;
  }
}
```

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