**Companion Cubes**

* Companion Cubes is an interactive installation that utilizes lights, arduinos, and photo-sensors to engage users in collaborative play. With the shape and scale of a children’s building block, but the aesthetic of a contemporary lamp, Companion Cubes encourages both children and adults to create unique forms and structures with the toy-like objects.
* Users interact with the installation by creating and breaking chain reactions of light with the individual lamps. A light chain is activated by using an external light source – like a flashlight or a phone – which then triggers any boxes within the predetermined range of sensitivity. Because of their rectilinear shape, lamps can be placed in rows, stacked, and placed at random. In presentations of this project, users have immediately experimented with how the chain reaction works and each lamp’s range of sensitivity, and then proceed to collaborate with the rest of the group to create interesting forms and reactions. A phone light can also be shone across multiple lights at once, allowing users to interfere with and reset chain reactions. Breaking the chains can also be fun for the group, with users working together to frantically break the chain reaction while the lamps work against them.
* **Hardware:** For the hardware, an arduino/microcontroller is attached to a soldered perf board that contains 3 LEDs as its output and 2 photoresistors as its input. A 9V battery is also connected to the arduino as its power source.
* **Software:** The code is uploaded from Arduino 1.8.5 onto the microcontroller which tells the arduino to receive the photoresistors as 2 separate inputs, to trigger all 3 LEDs with a fade-in and fade-out effect when either photoresistor receives an input above a certain threshold – which is calibrated to the ambient light of the current room of the project – and to trigger the lights at a randomized delay. The randomized delay occurs within a range of .5 to 1 seconds and prevents the lamps from reacting to themselves, which would cause infinite loops, instead of a chain reaction. The delay is randomized instead of constant to create a twinkling effect within the chain reaction.

**Photobioreactor**

* “We believe that, if human beings are part of an ecology, then the objects humans make should also be part of it. Among humans and insects alike, inhabitable spaces are the result of a deliberate organization of material, energy, information and a continuous interaction with the environment, whose goal is to help develop tight-knit communities.”
* The purpose of this project is to design a photobioreactor in an urban environment for the production and consumption of future food - specifically the micro algae spirulina.
* The shape of the brain coral lends itself readily to the form of a tubular photobioreactor, with winding hills and valleys representing the tubes themselves. Brain Corals exist symbiotically with algae (algae can be seen in the image above within the coral’s valleys); the algae depends on the stony coral for structure while the coral depends on the algae for food.
* A brain coral pattern can be generated using a couple of different algorithms, particularly through the concepts of reaction-diffusion and differential growth. Reaction-diffusion is pixel or grid based simulation that forms all at once, instead of gradually from an initial position – which is not how an actual brain coral grows in nature. As a result, for this project a differential growth algorithm was used. Differential growth is a concept that can be simply described as growth that changes as it forms.
* In this case, differential growth is generated using a mass-spring system - a physics simulation that treats lines and surfaces as springs in tension. This algorithm, based on the work of Daniel Piker, works through line expansion growth. An initial line is segmented into individual springs and grows through lengthening each spring individually with collision detection. Spheres drawn on each point of division provide the collision detection, and as a result a hexagonal organization will naturally occur (circles tend to organize into a hexagonal grid).
* The photobioreactor was fabricated with hand-blown glass by a local glass artist. The glass sculpture is then backed with an arduino controlled LED panel that pulses with the same timing as a heartbeat. The time increments between the LED flashes is decreased when approached - through the use of motion sensors. The differential widths of the glass channels were designed to optimize the flow of spirulina, with smaller widths increasing flow speed upward against gravity and larger widths only in areas where gravity assists the water flow. For its exhibition at IAAC, the photobioreactor was mounted on 3 wooden panels that were CNC milled to show the continuation of the pattern as it would be in reality.

**Breathing Plaza**

The goal of the Breathing Plaza is to create a space that reacts in real time to use. If a person enters the plaza, the structure will slowly envelop them, creating a bubble-like retreat from the outside. If a group of people enter, a larger bubble will form - creating an intimate meeting environment. The adaptations of the plaza are telegraphed visually to passersby and users within, allowing them to either join or avoid.

I conducted multiple experiments on both the actuators themselves and the connections of these actuators into a larger system. Each actuator is composed using similar concepts and components - an inner balloon is encased within a diamond braided mesh fabric - which when inflated restricts the normal expansion of the balloon instead into linear contraction.

Later experiments build off this concept - switching out the balloon for a silicone bladder and the mesh for a ribbon (braided with the same diamond pattern to create the necessary contraction). An inextensible material - in this case a simple strip of paper - was also introduced in an effort to change the direction of the contraction.

Two systems came of these experiments - the first using the pneumatic muscles (experiment 1) to pull on an elastic fabric to change the shape of its surface (experiment 7), and the second using the chained combo actuators (experiment 6) to create a surface made completely of the actuators themselves (experiment 8).

The idea of an adaptive plaza is translated into a system of artificial muscles and capacitive sensors that respond and react to physical proximity. Capacitive Sensors: Three capacitive sensors are used to trigger the valves in the balloons. When the capacitor is touched the valves close, allowing air to build up within the actuator. Diamond Braided Mesh Sleeve: A very specific woven mesh is required to create an artificial muscle. To actuate the contracting motion of the muscle, a woven pattern that generates a scissor motion is required. When the balloon inflates laterally, the mesh is stretched outward, which as a result - through the scissor motion - contracts the muscle vertically. Adaptive Fabric: With both the top and the bottom of the prototype being pulled upon by the muscles, the displacement is split between both sides. Gravity also assists the top fabric’s deformation, while the weight from the users hinders the bottom layer’s ability to deform. Therefore, a more flexible material was chosen for the bottom layer. Additionally, to maximize the deformation from below, a rigid fabric was chosen for the upper layer. Through calibration of these materials, any configuration can be achieved.

* Using Galapagos, I simulated different use conditions - in which people within the structure “moved around” to generate both the most and the least displacement. The goal was to test my own assumptions of how the proximities of people to these programmed “sensors” would actually affect the system. I was able to more effectively edit the system’s sensing technique as a result of these tests.
* Because displacement in this script is based on proximity, when large clusters of people are formed there is greater displacement, but when the points are spread across evenly, there is only localized displacement. Additionally, because the highest level of proximity supercedes lower levels, when points are packed extremely tightly the lowest possible displacement would occur; the system would effectively respond as though there was only one point instead of ten.