Shadow Fish

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Study On The Puffer Fish

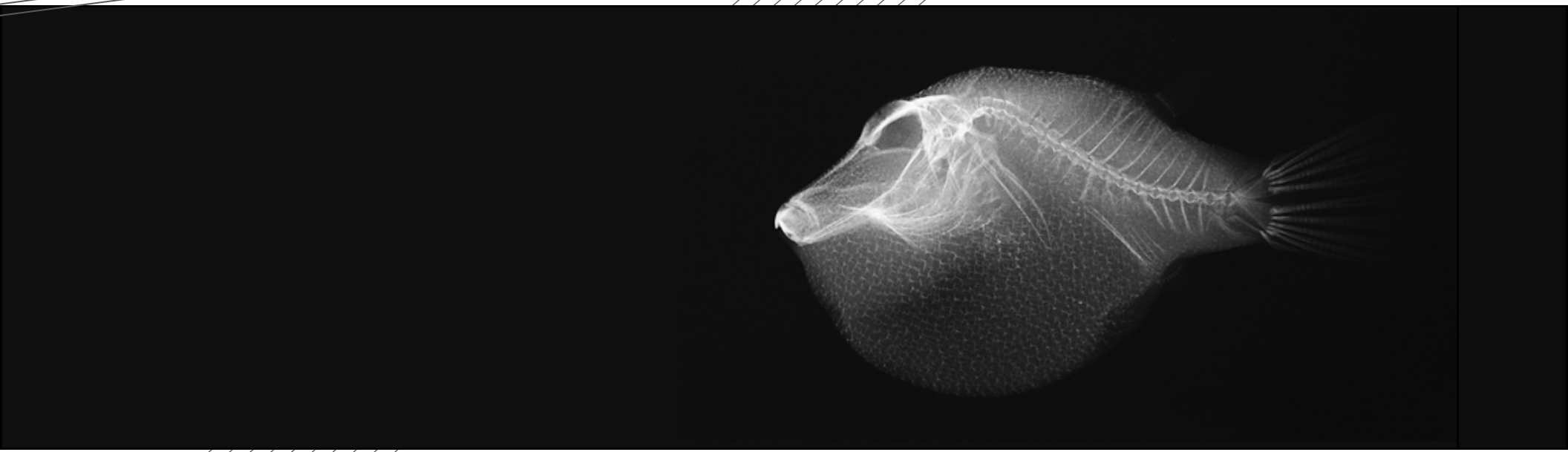

Figure 1 X-ray of a puffer fish

http://www.showyourfishes.com/Sharpnose_puffer_fish/

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1. Introduction

Pufferfish are sea creatures that can inflate themselves with water, or air, in order to defend itself. Some are also able extrude sharp spikes from their body upon inflation. The idea of automatic inflation and extruding spikes greatly interested our team. We decided to study the Pufferfish and learn as much as possible about their inflation and erecting spike functionalities.

Our intent is to take these seemingly complex functions of the Pufferfish, and create a simple model of either or. Eventually, we plan on designing an architectural application based upon our findings and model designs of the Pufferfish.

Figure 2 X-ray of a puffer fish

http://thecreativefinder.com/portfolio-image.php?username=holoman&id=49718&filename=X-rayfugupufferfish.jpg&title=X-ry%20fugu%20puffer%20fish

Puffer Fish

Puffer fish are extremely good at protecting themselves. As a defense mechanism, the puffer fish "puffs" itself up, thereby making it harder for a predator to consume it. Not only does it grow in size, but the puffer fish extrudes sharp spikes from its body. Puffer fish can take about 35 gulps of water in 14 seconds in order to inflate themselves. [1]

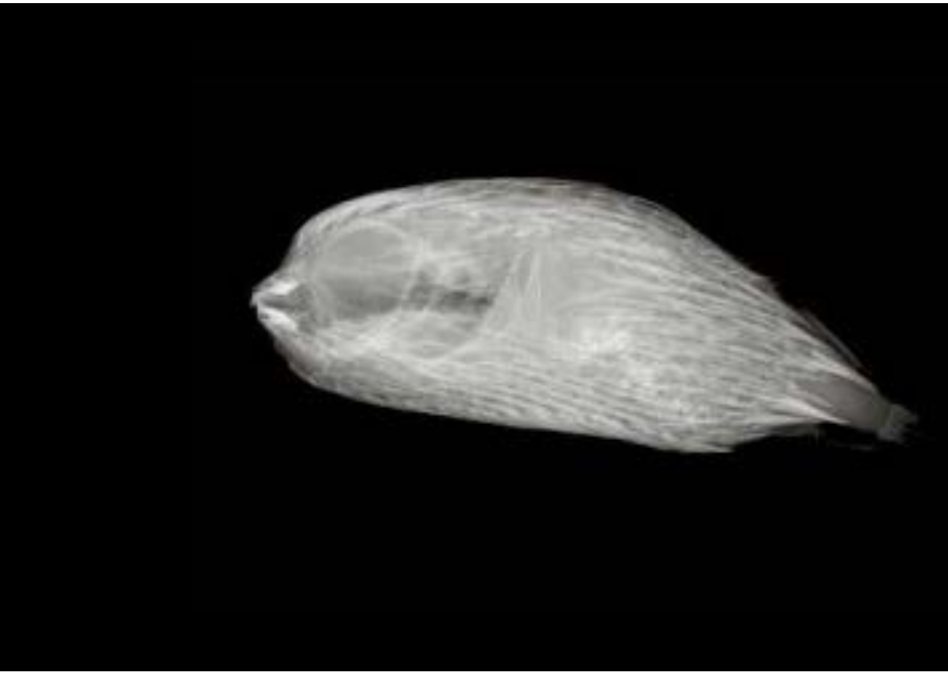


Figure 3 X-Ray of Puffer Fish Normal Status

http://discovermagazine.com/galleries/zen-photo/x/xray-fish#.UIzmgWRhtcQ

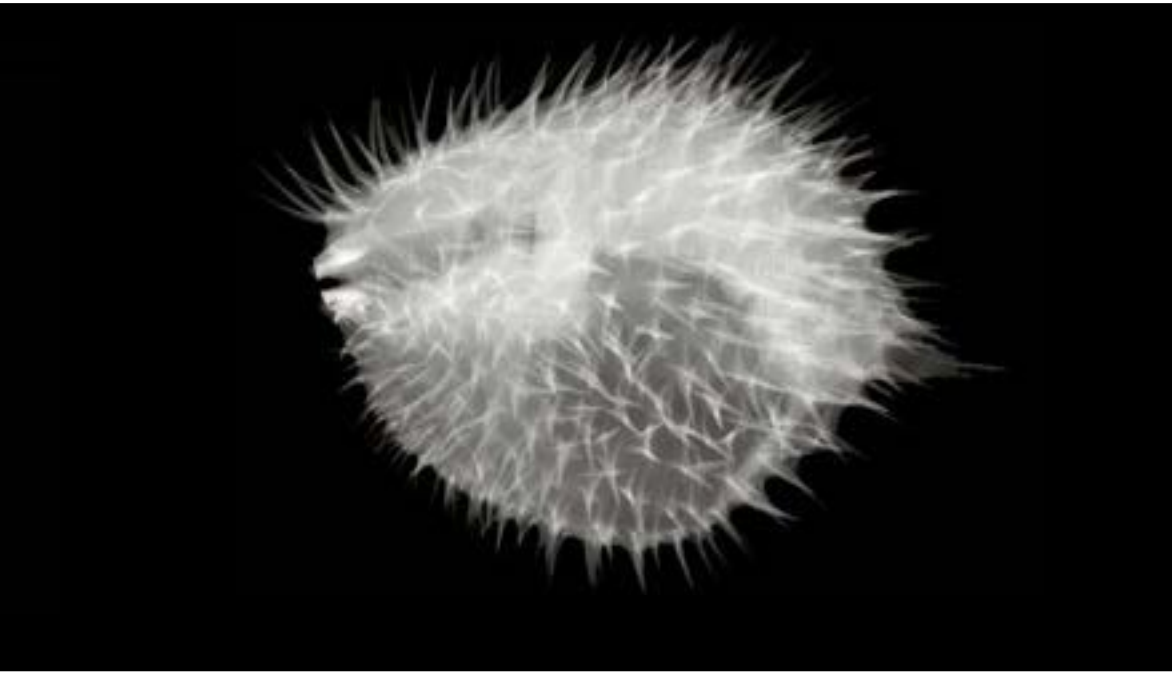


Figure 4 X- Ray of Puffer Fish Puffing once they realize dangerous

http://discovermagazine.com/galleries/zen-photo/x/xray-fish#.UIzmgWRhtcQ

2. Biology study

Inflation

Puffer fish "close their gill slits and use muscles on the side of their "faces" to force water in or out. [4] However, in order to forcibly intake or expel water, the fish contract their coughing muscles "for longer…and [constrict] their mouths in order to get a smaller, more powerful stream." [4]

First, the fish takes in as much water as its mouth can hold. Next, there is a special valve like object near the fishes' esophagus that "flaps upward and covers the entire mouth." [5] Finally, an arch pushes the water into the fish's elastic stomach. To add to their already extensive list of abilities, the fish have stretchy skin and stomach, but no ribs.

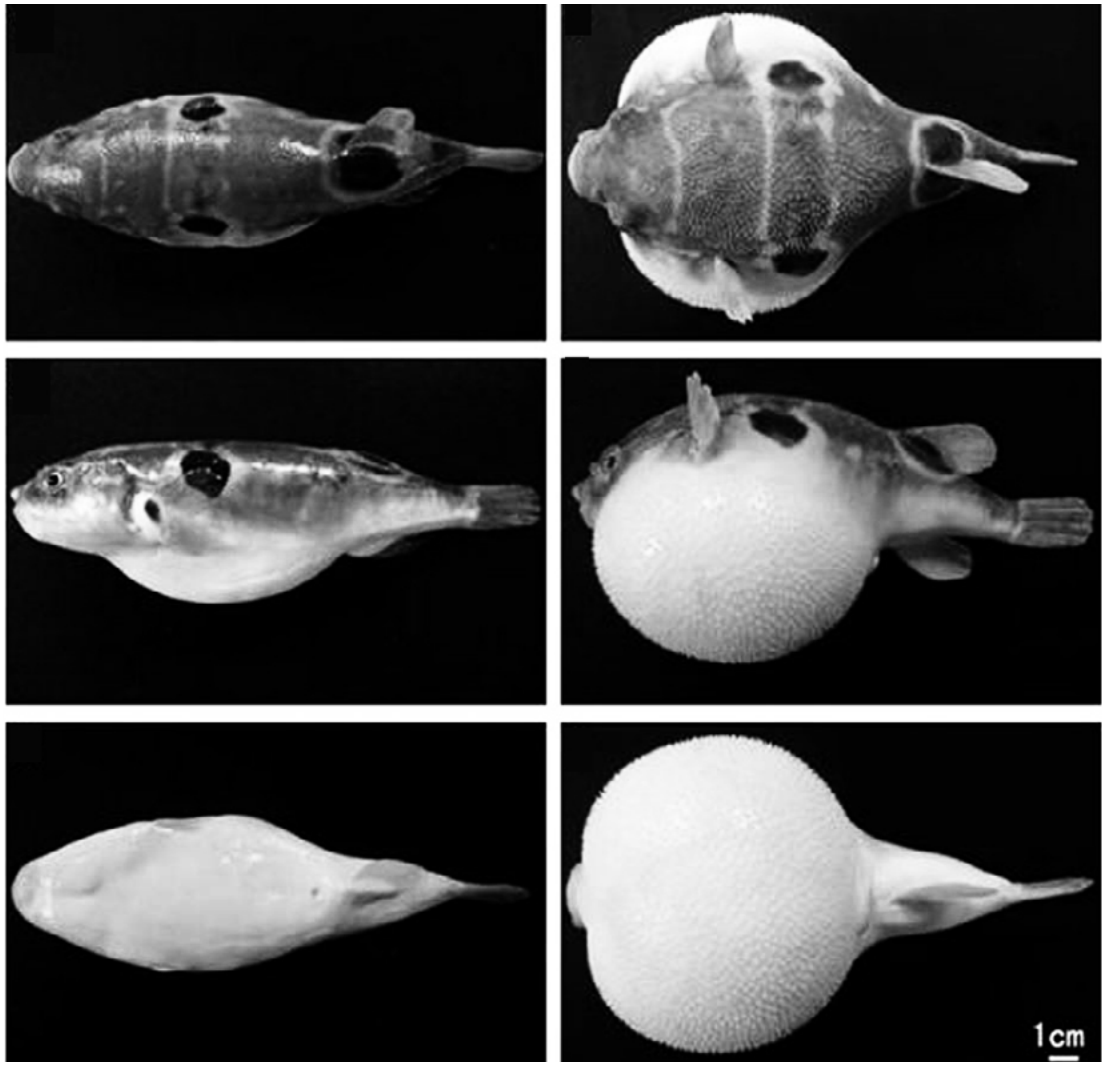


Figure 5 The change of body shape in unflated and inflated pufferfish

http://www.bioline.org.br/pdf?zr10073

2. Biology Study

The Head

Normally, fishes' heads "are usually firmly attached to their shoulders, over puffer's head are hinged, which allows them to dramatically increase the size of their mouth cavities." [4]

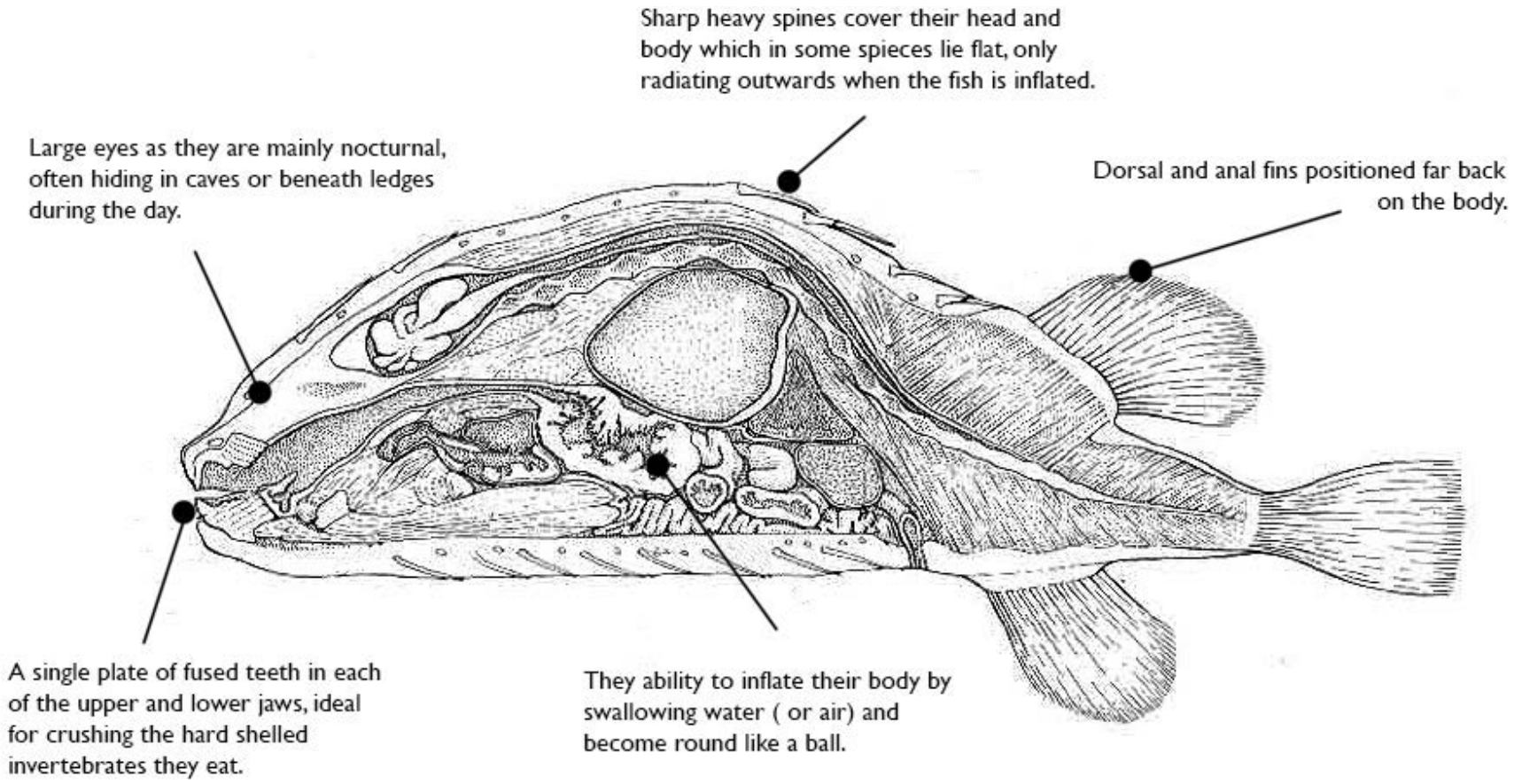


Figure 6 Puffer fish Section

3. System

Both images on the right are cross sections of a long-spined pufferfish. The top half of Figure 3 is an uninflated balloonfish, which shows the "folded peritoneal lining, the folded, papillated stomach, and the absence of median hemal processes on the abdominal vertebrae" [8a] The bottom half is shows a possible level of inflation in the pufferfish and the "ventral skin retracted," but with a "portion of the dorsal musulature removed" [8a]

Upon inflation, "large folds in the peritoneum allow the stomach and the peritoneal cavity to expand craniad to the tip of the mandible and caucad to engulf the unpaired fins" [8b & (peritoneal folds Fig 3)]. The spinal structure of pufferfish also add to their ability to become spherical. When inflated, their spine bends in a "concave side toward the ventrum of the fish)" [8b].

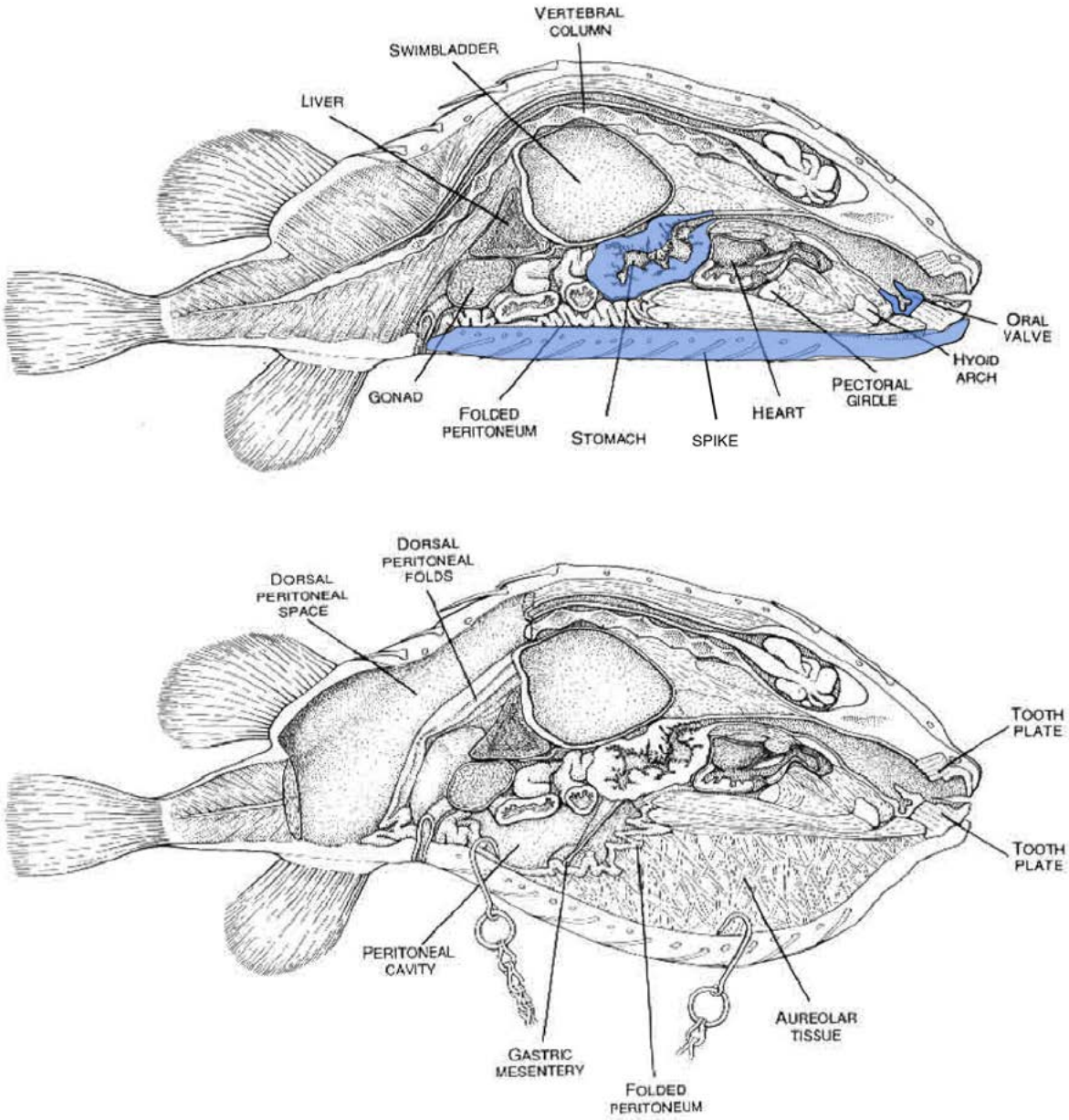


Figure 7 Pufferfish Section related to puffing mechnism

http://www.brown.edu/Departments/EEB/brainerd_lab/pdf/Brainerd-1994-jmorph.pdf

4. Prototypes

Characteristics

1. Goal:

The function we are looking for is how we can control elements direction and rotation upon the surface, such as spike, by amount of inflation (achieved by air force).

2. Process:

Testing different surface patterns and thicknesses, so that various amount of inflation in model can be achieved.

Then, the place of spikes can be defined based on the variable inflation.

2. Type of Material

Silicone - freedom in finding variety of forms.

3. Air Application

Air Pump/Valves system are controlling by arduino, so that the amount of air inside the models can be adjusted.

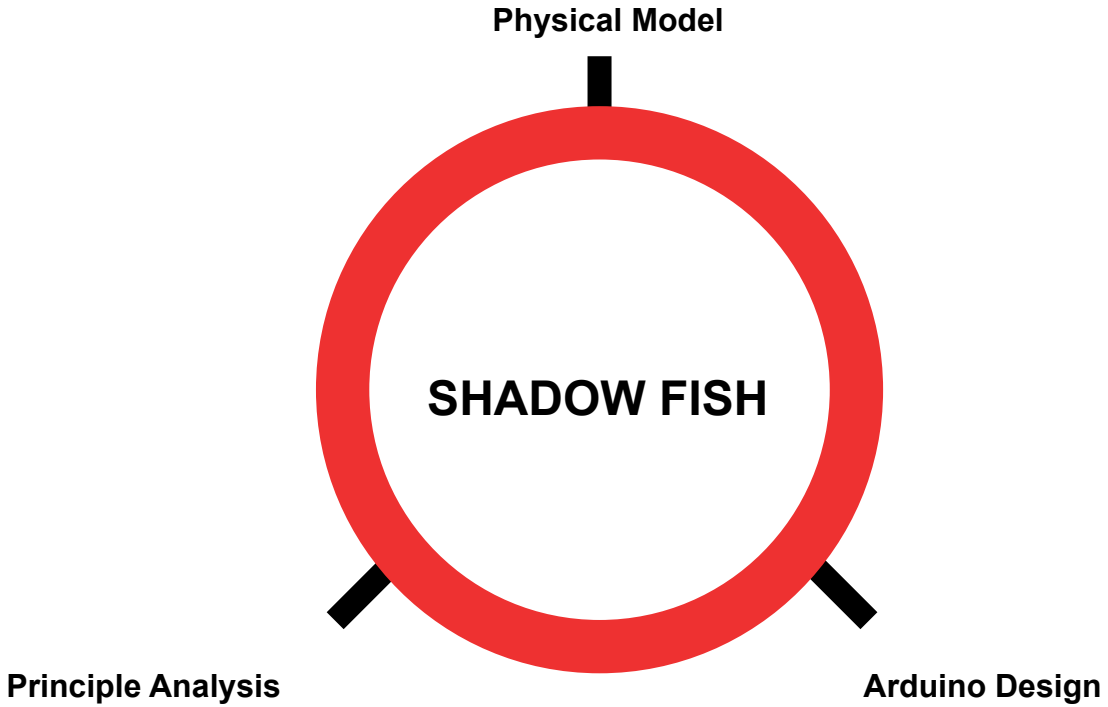


Figure 8 Shadow Fish project structure

4. Prototypes- Physical models

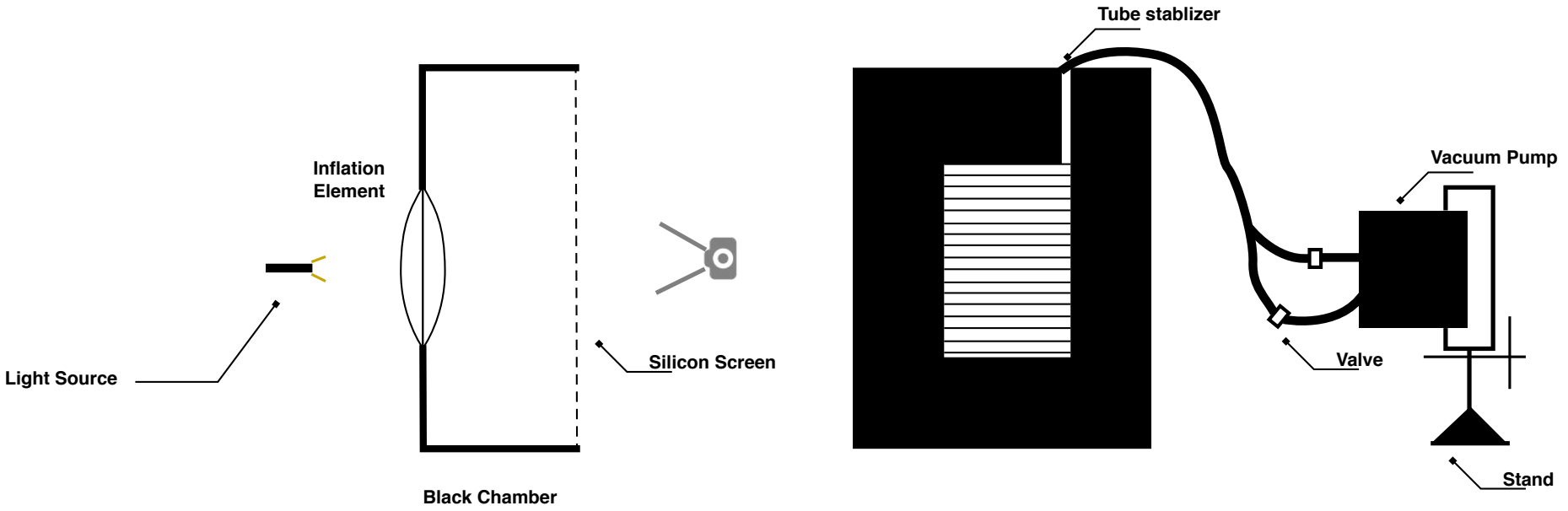
Although idea of the prototype was successful, the physical construction of the model and the actual effect of the shading pad was not strongly successful as the idea itself.

So the actually physical model of the prototype is providing shades by combining the characteristics of the inflation material and the shading material, which is attaching inside of the prototype.

Figure9 Shadow Fish Physical Model-Chamber

4. Prototypes- Physical models

The prototype is made of a black chamber attached with the inflation element. At the back, the face of the black box is a screen, made of silicon, to show the shading effect created by the lights going through.



TOP VIEW

FRONT VIEW

Figure10 Shadow Fish Physical Model-Chamber Illustration

4. Prototypes- Physical models

The second key part of the prototype is the vacuum pump, which can both blow up air and exhaust air.

Tubes and Valves are connecting the black chamber and the vacuum pump.

Figure11 Shadow Fish Physical Model-Vacuum Pump

4. Prototypes- Arduino

In order for our component (and possibly the entire system) to be a stand-alone unit, we decided to get some help from an Arduino microcontroller. One of our first designs for how the arduino would interact with our component is on the right.

The arduino controls the solenoid which allows air to pass freely into our shadow fish. The light sensor senses how much light is shining near or on the shadow fish and relays that information back to the arduino. Depending on the amount of light, the component self inflates. The only issue that arose from the prototype is that we realized that there was no way for the component to deflate itself.

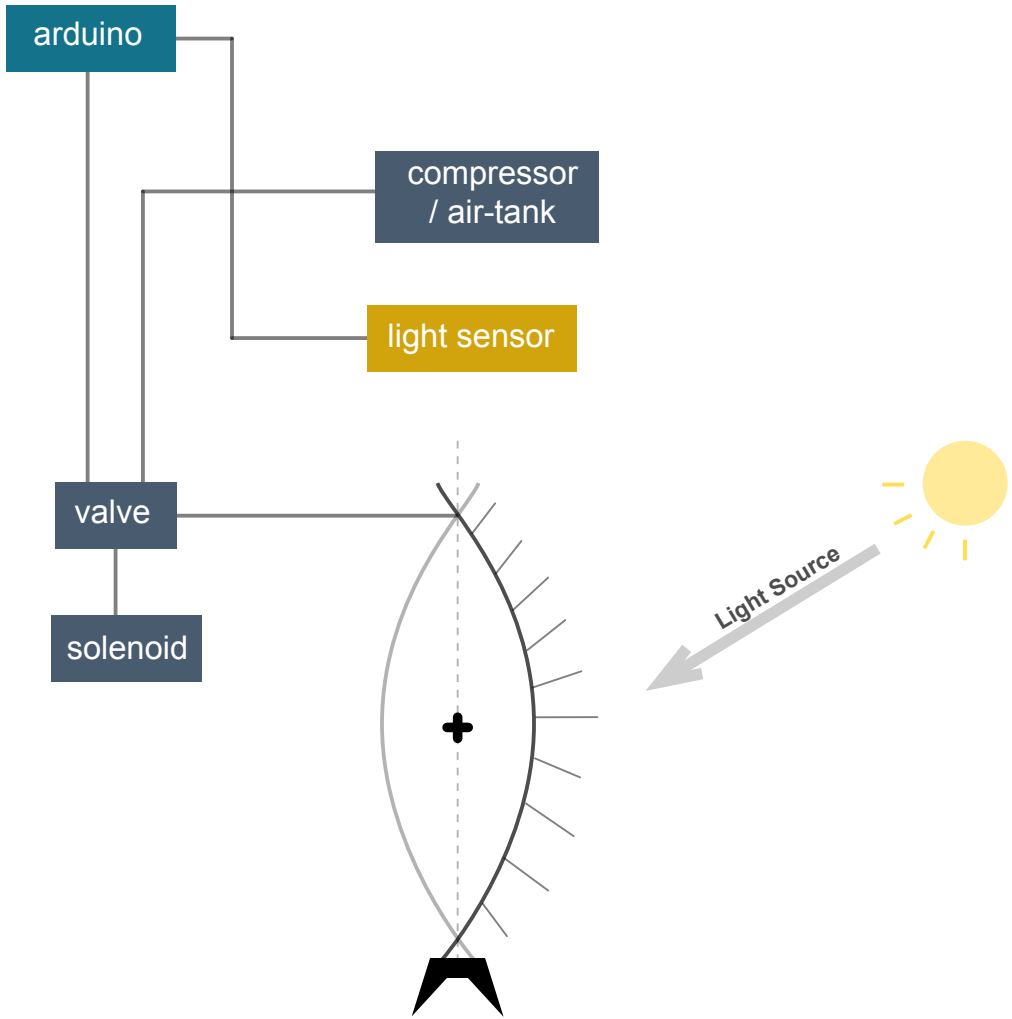


Figure12 Shadow Fish Arduino Structure

4. Prototypes- Arduino v2

In the arduino redesign, we were able to purchase a vacuum pump: a component that blows and vacuums air from two different outputs. We connected tubing to both sides of the pump. In addition, we used a Y valve and attached two servo motors to each valve. The servo motors are supposed to be connected to the arduino. Depending on the amount of light, the light sensor sends a signal to the arduino, and the arduino tells which servo motor to open its valve: the deflating side, or the inflating side.

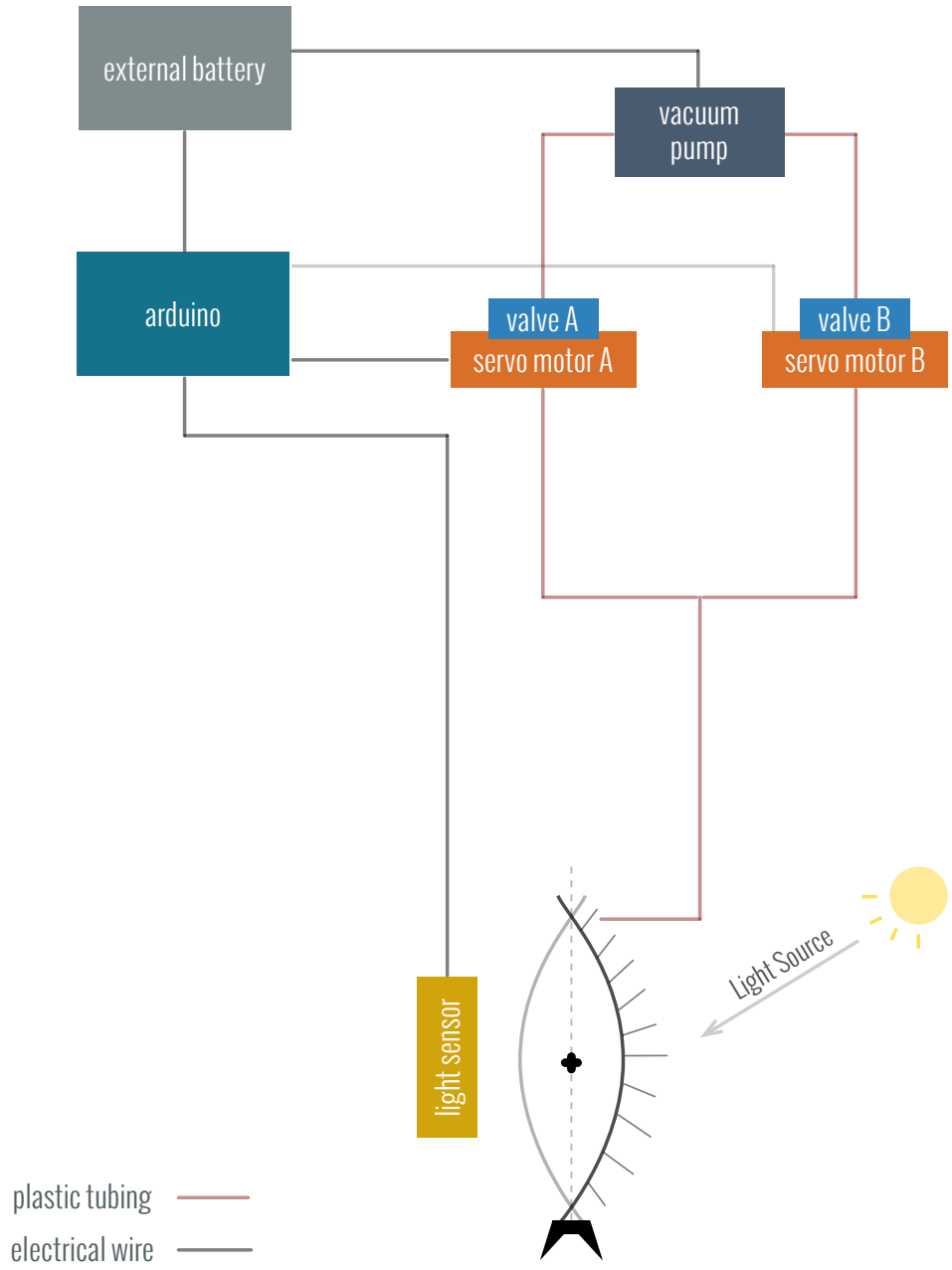


Figure13 Shadow Fish Arduino Structure

4. Prototypes- Principle analysis

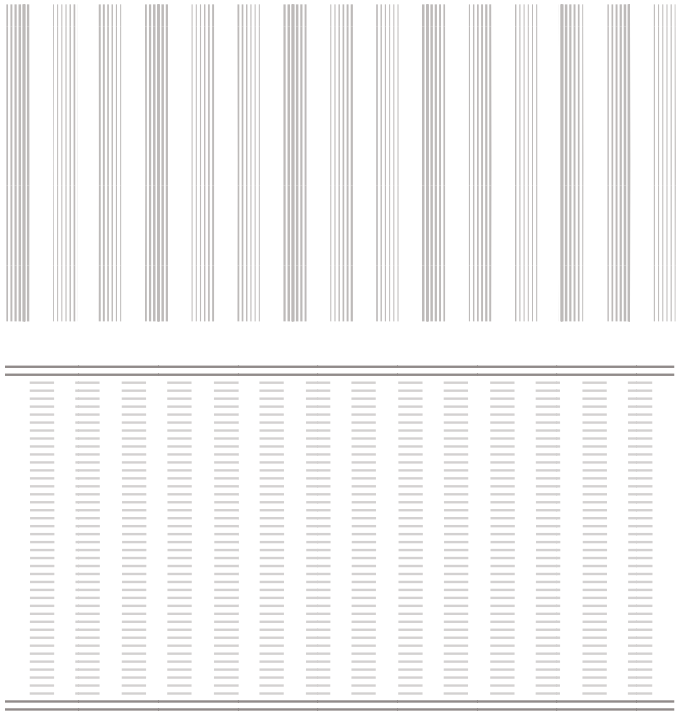


Figure14 Shading Material Invisible Pattern

The property of the shading material is a key contributer to this prototype. This material has invisible patterns, like what you can see in the diagram. Therefore, if one pattern is attached to one side of the inflation part, and the opposite pattern is attached to the other side of the inflation part, there will be shades created by the overlapping.

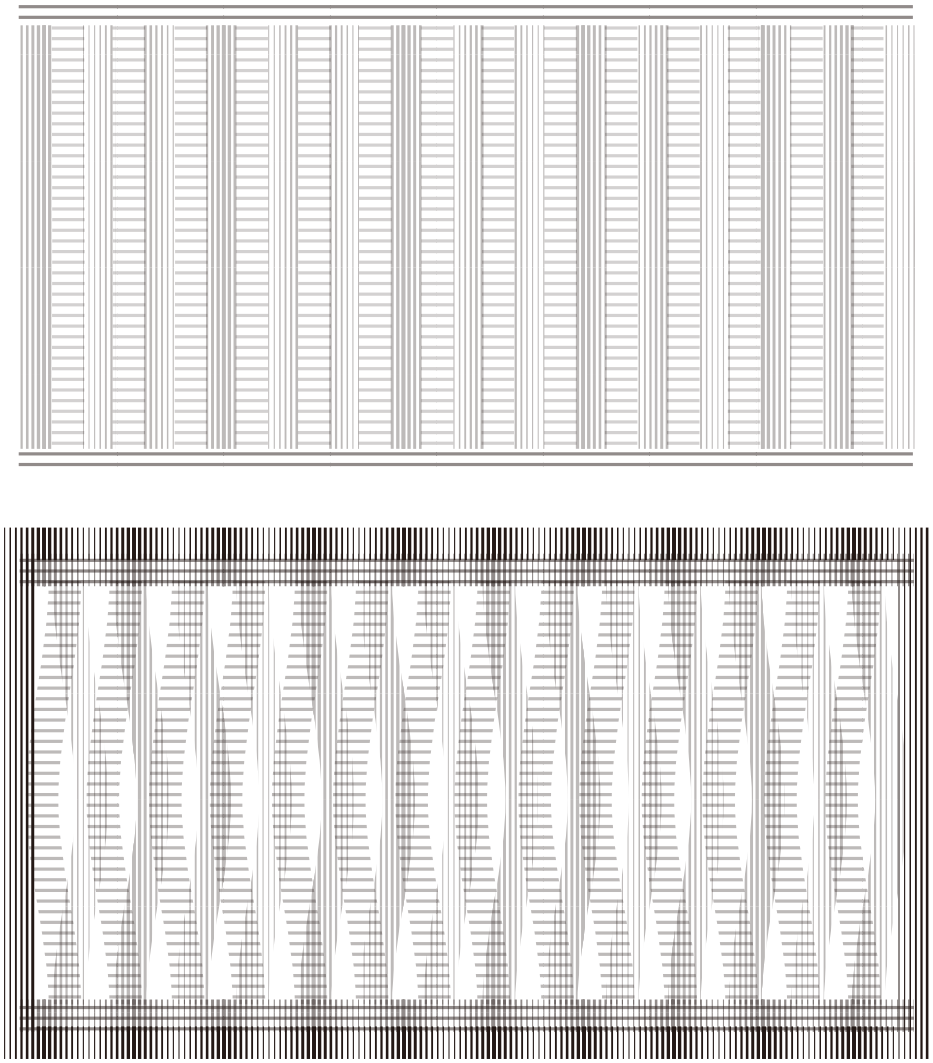


Figure15 Inflating Status of the prototype

5. Application

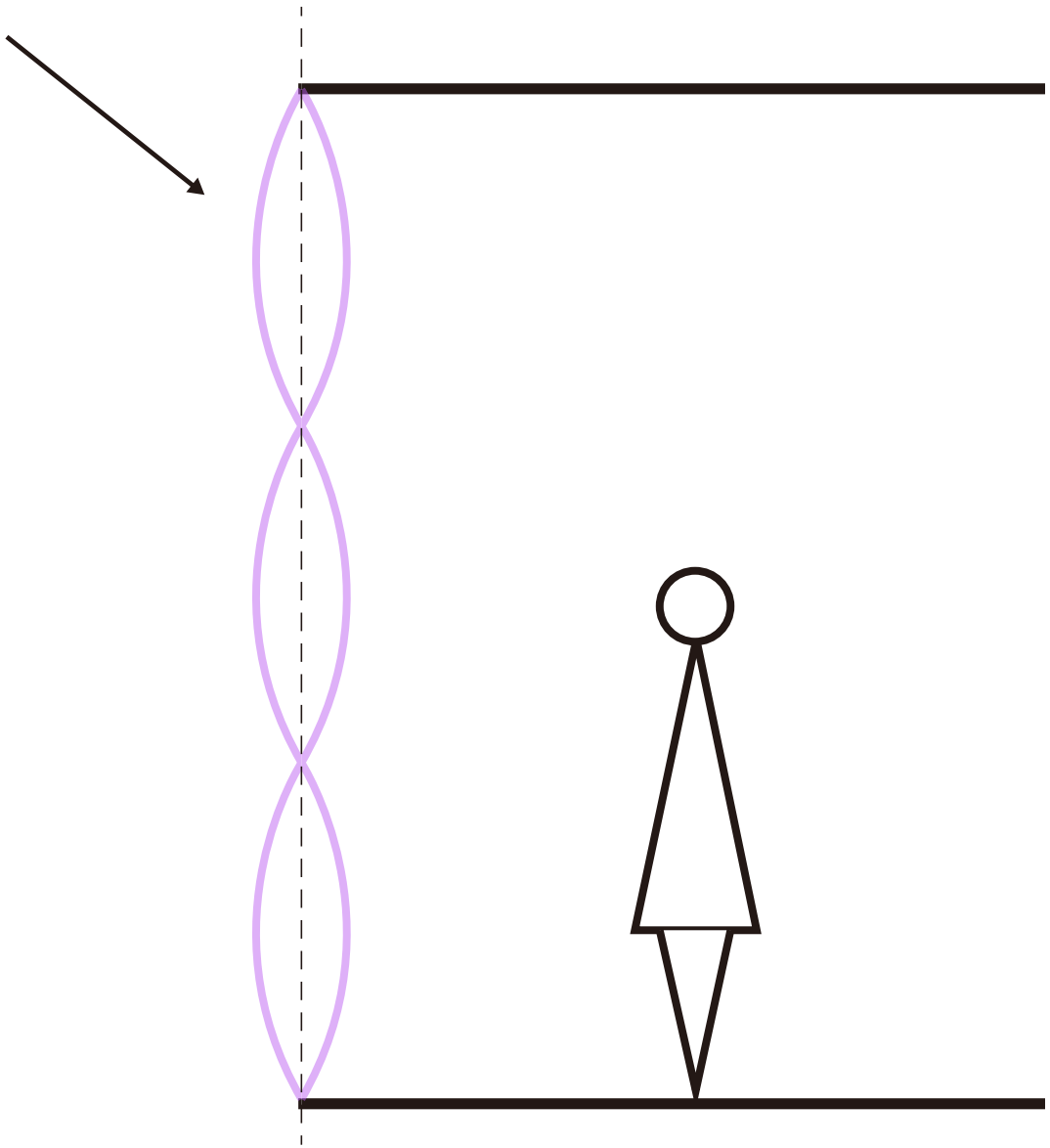


Figure16 Shadow Fish Application

This prototype can be used as the elements of an architecture facade to create shading and reduce the amount of sunlight going inside of the building.

This can be applied in the hot area in the South, such as Arizona, where they need less sunlight to reduce heat.

6. Former Analysis

Before the achievement of the prototype presented by the physical model, there were more studies about the prototypes which are valuable to the process of getting the final prototype.

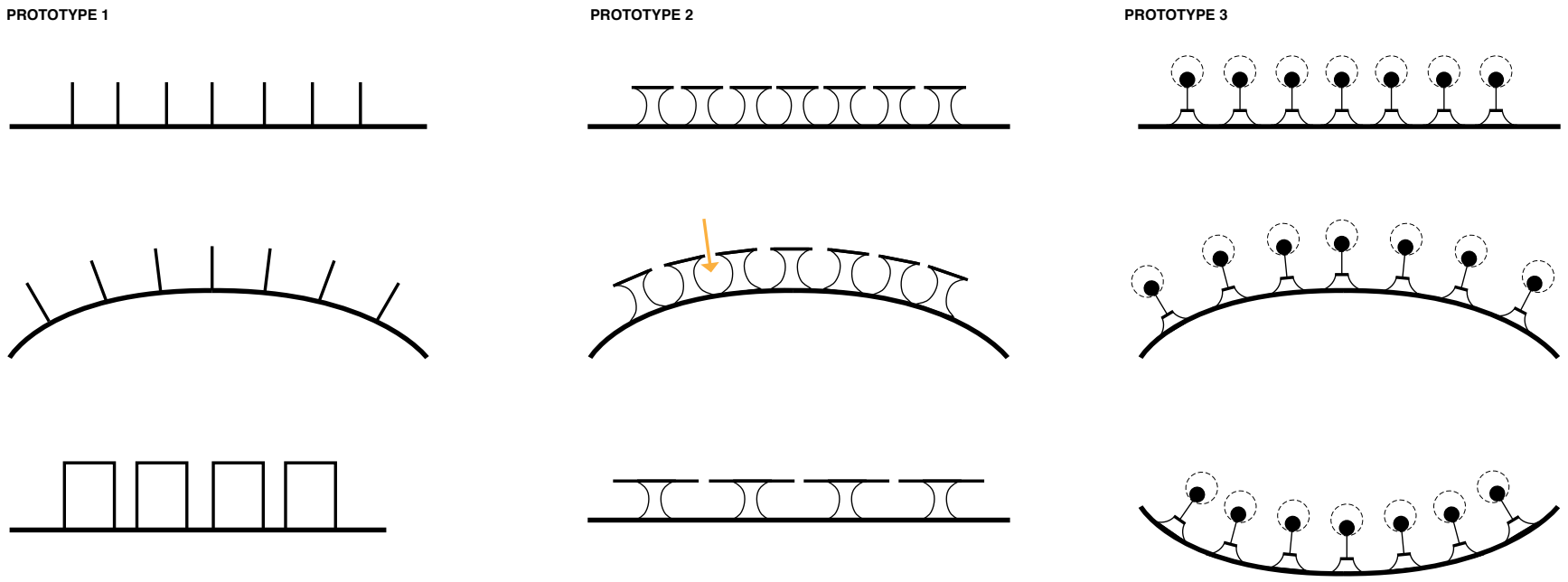
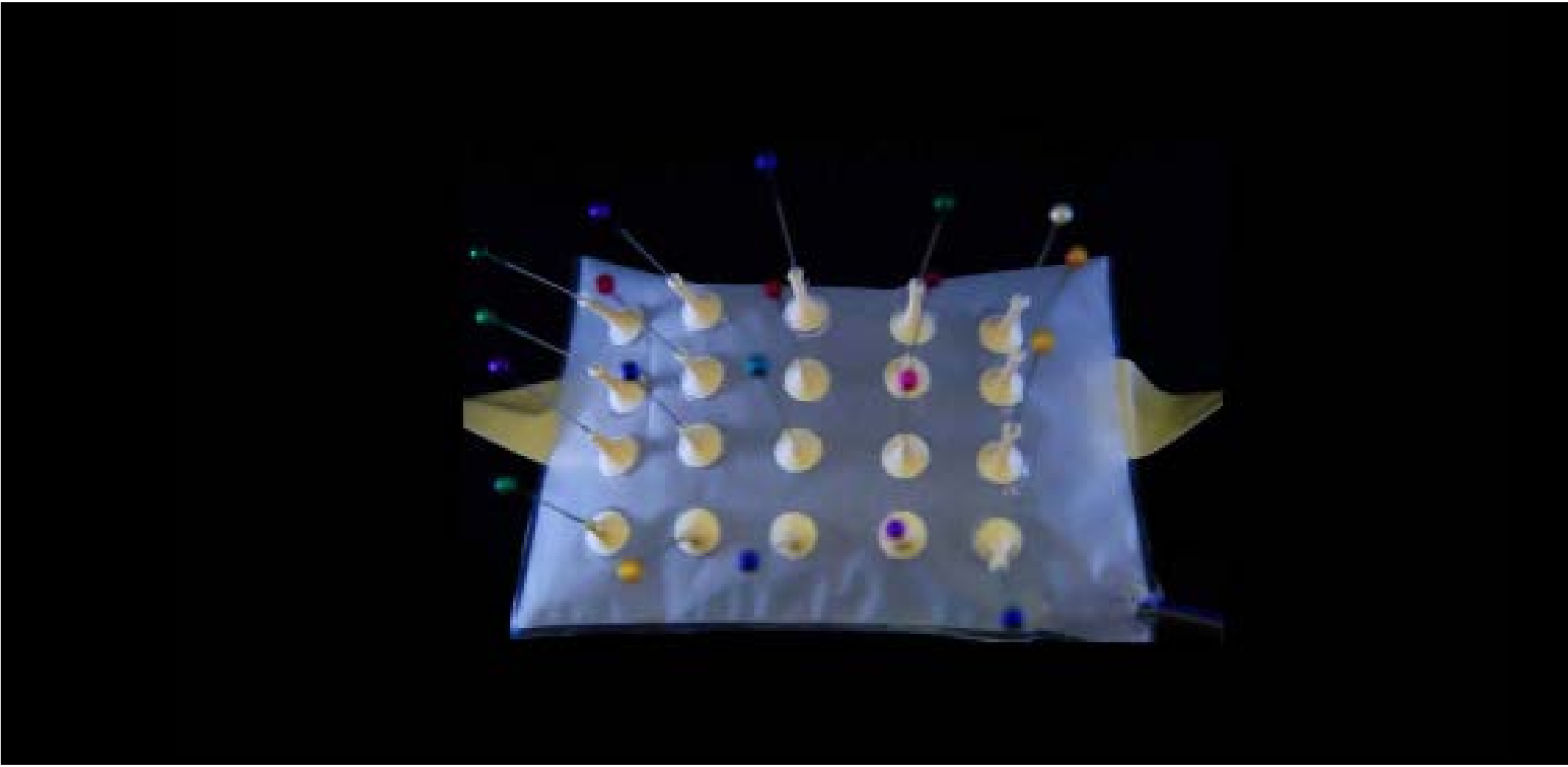


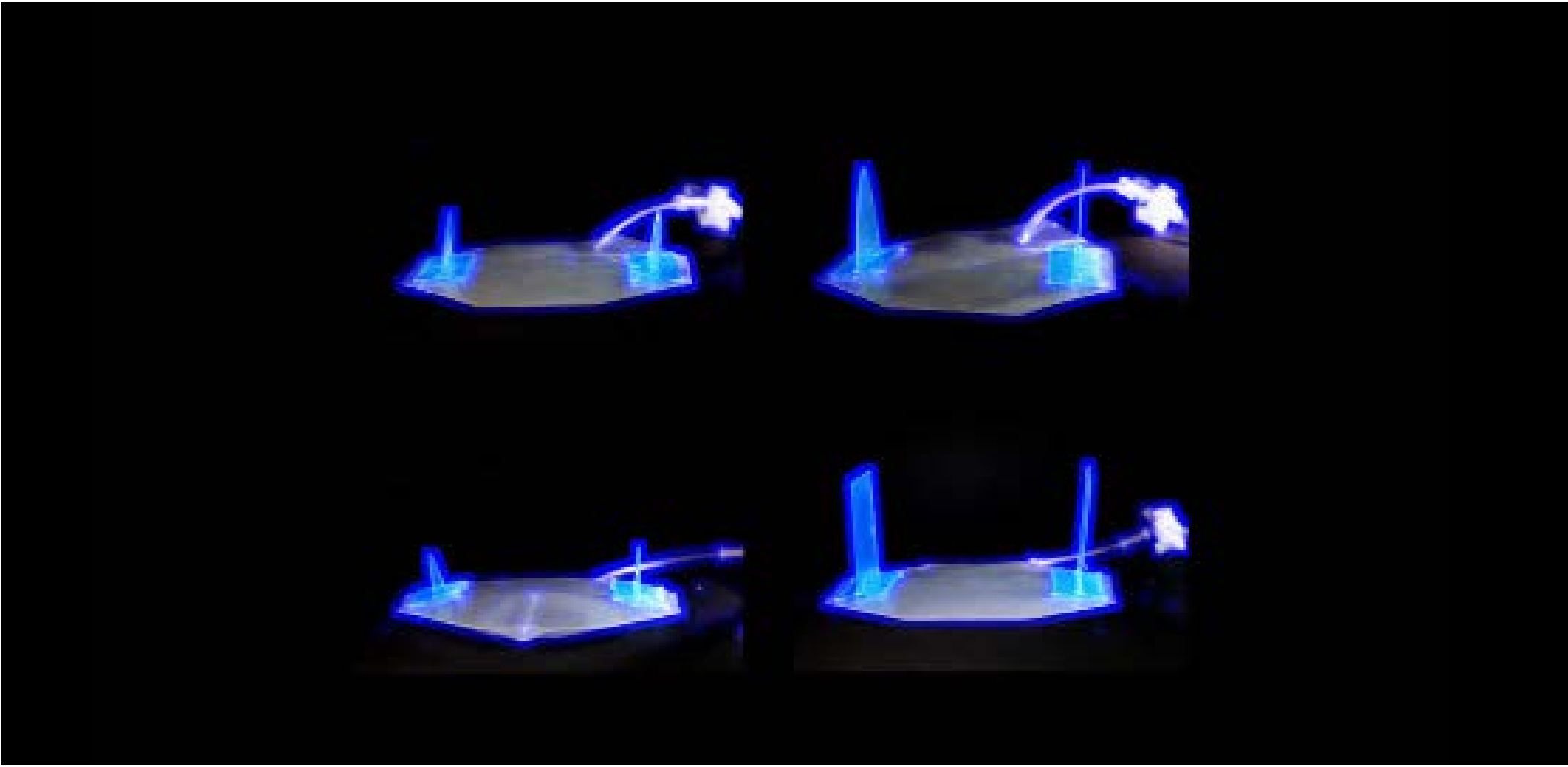
Figure 17 Simulation Prototypes

6. Former Analysis



Video 1 Prototype inflation tests

6. Former Analysis



Video 2 Prototype inflation tests

6. Former Analysis

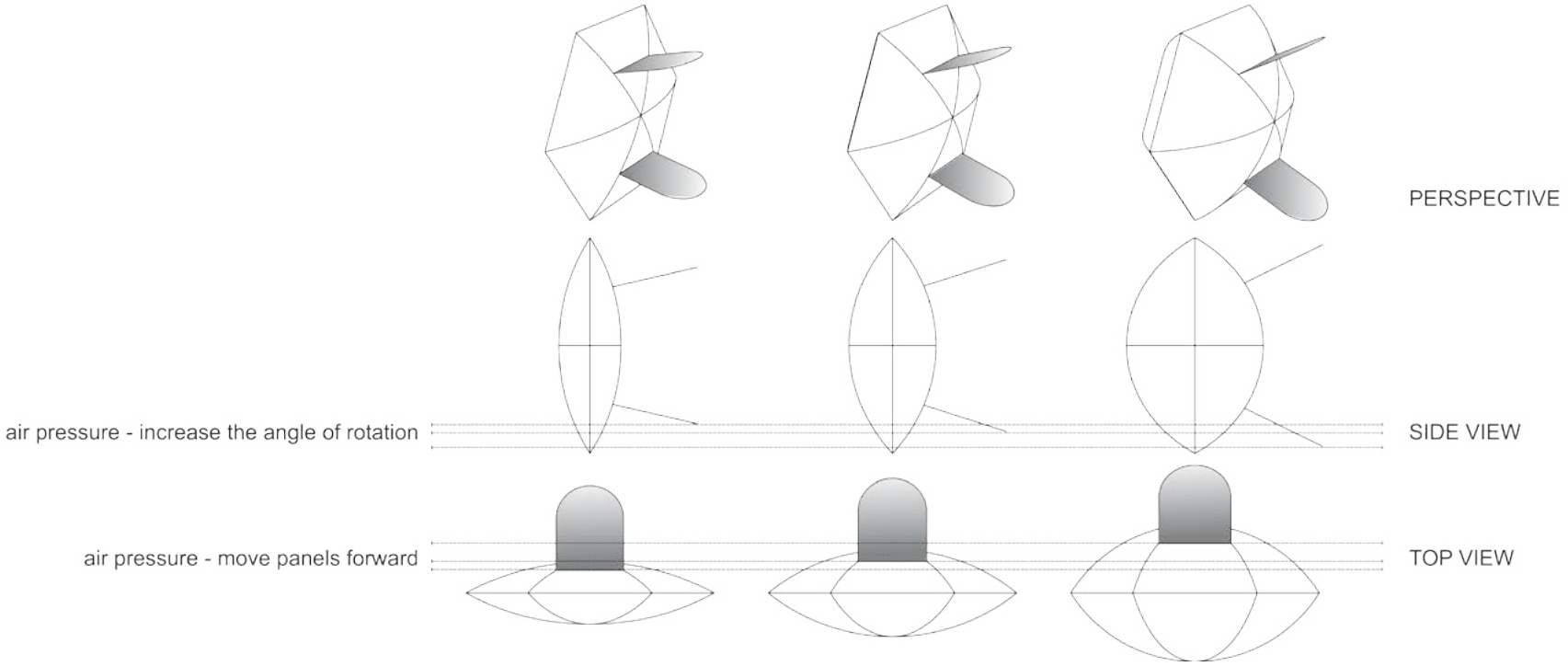
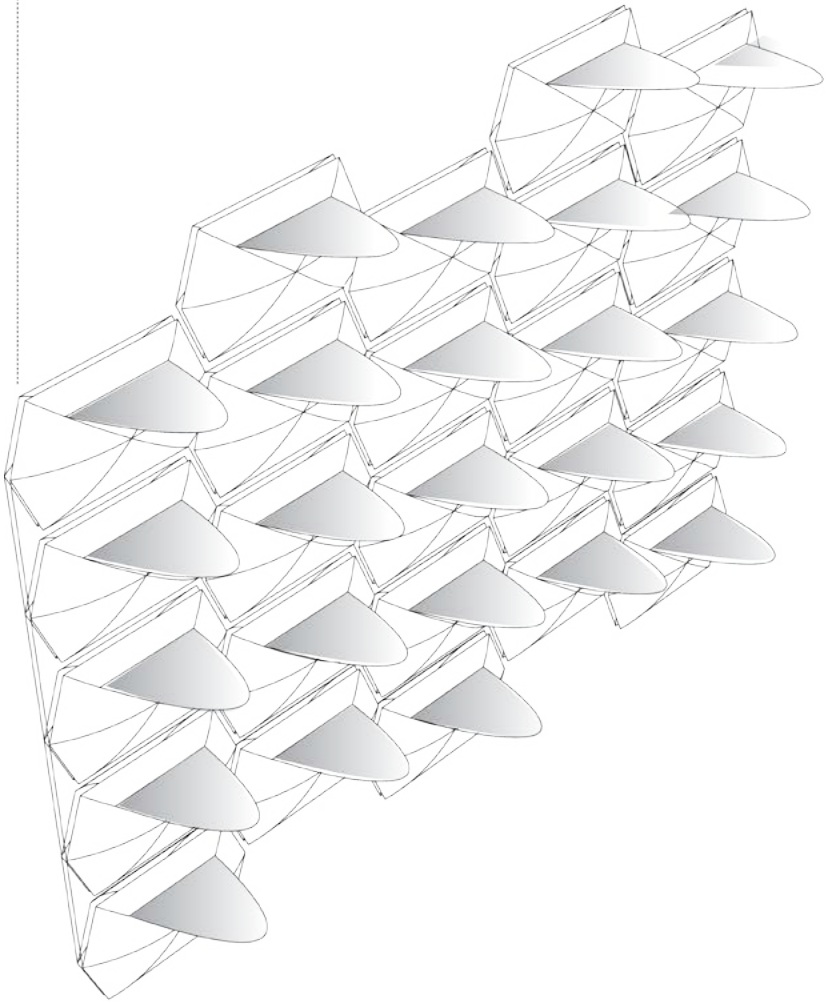


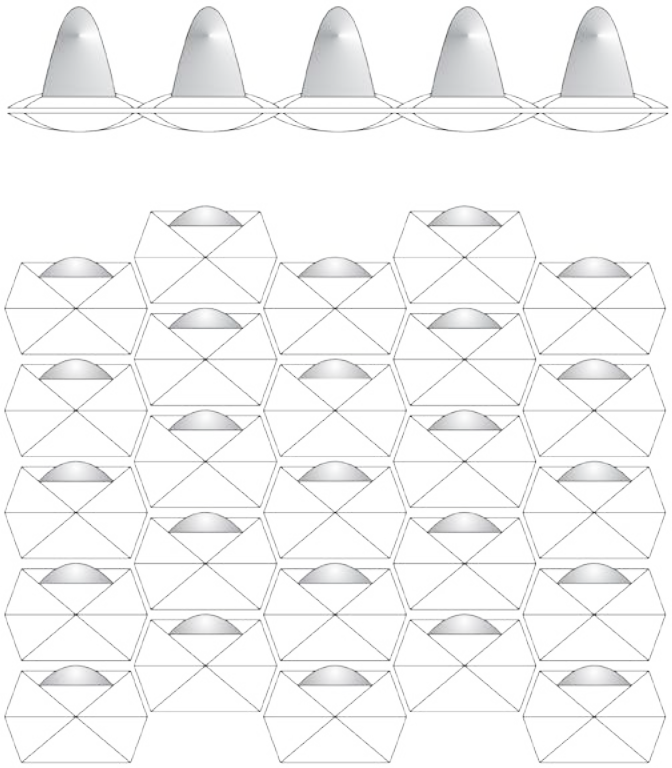
Figure18 Shadow Fish Former Prototypes Analysis

6. Former Analysis

PERSPECTIVE | geometry of inflatable components & panel Installation



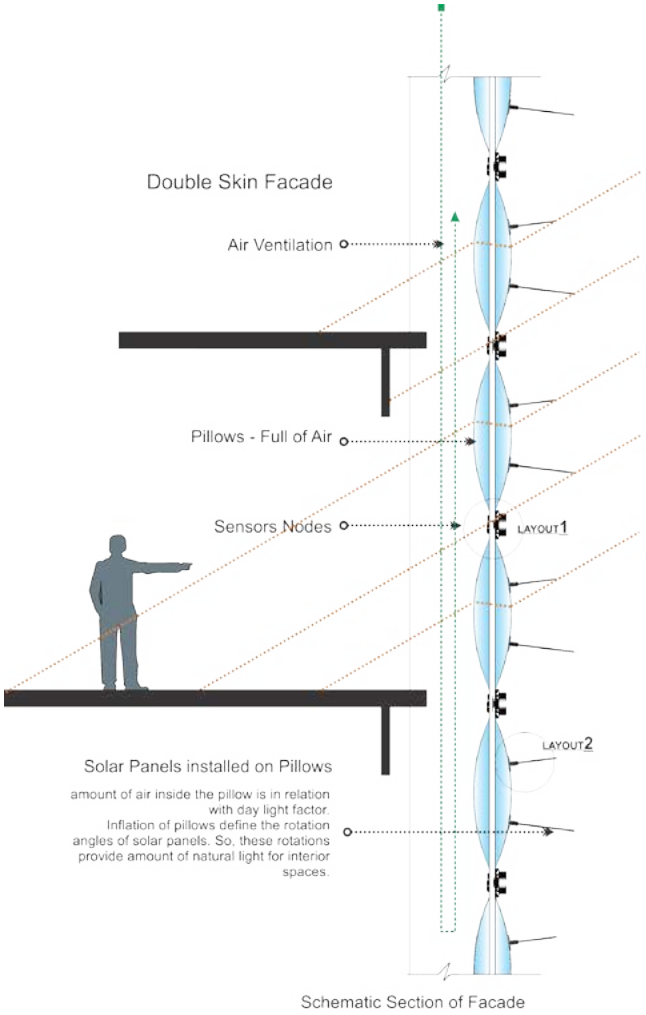
TOP VIEW | Weaving on the facade



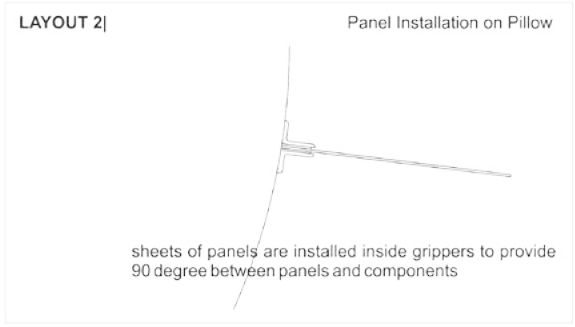
ELEVATION | different sun light angle provides different amount of inflation in components and this variability in inflation change the angle of panels on the facade.
so, panels during hours a day have seen with different areas on the facade.

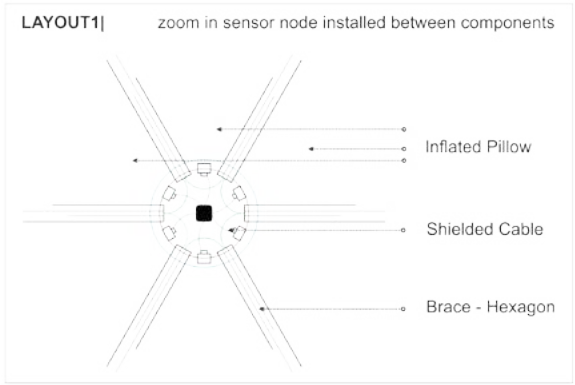
Figure19 Shadow Fish Former Prototypes Analysis

6. Former Analysis



Schematic Section of Facade





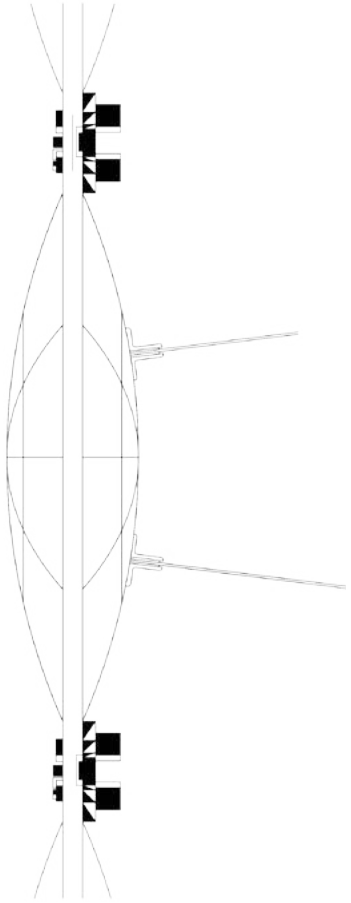


Figure20 Shadow Fish Former Prototypes Analysis

6. Former Analysis

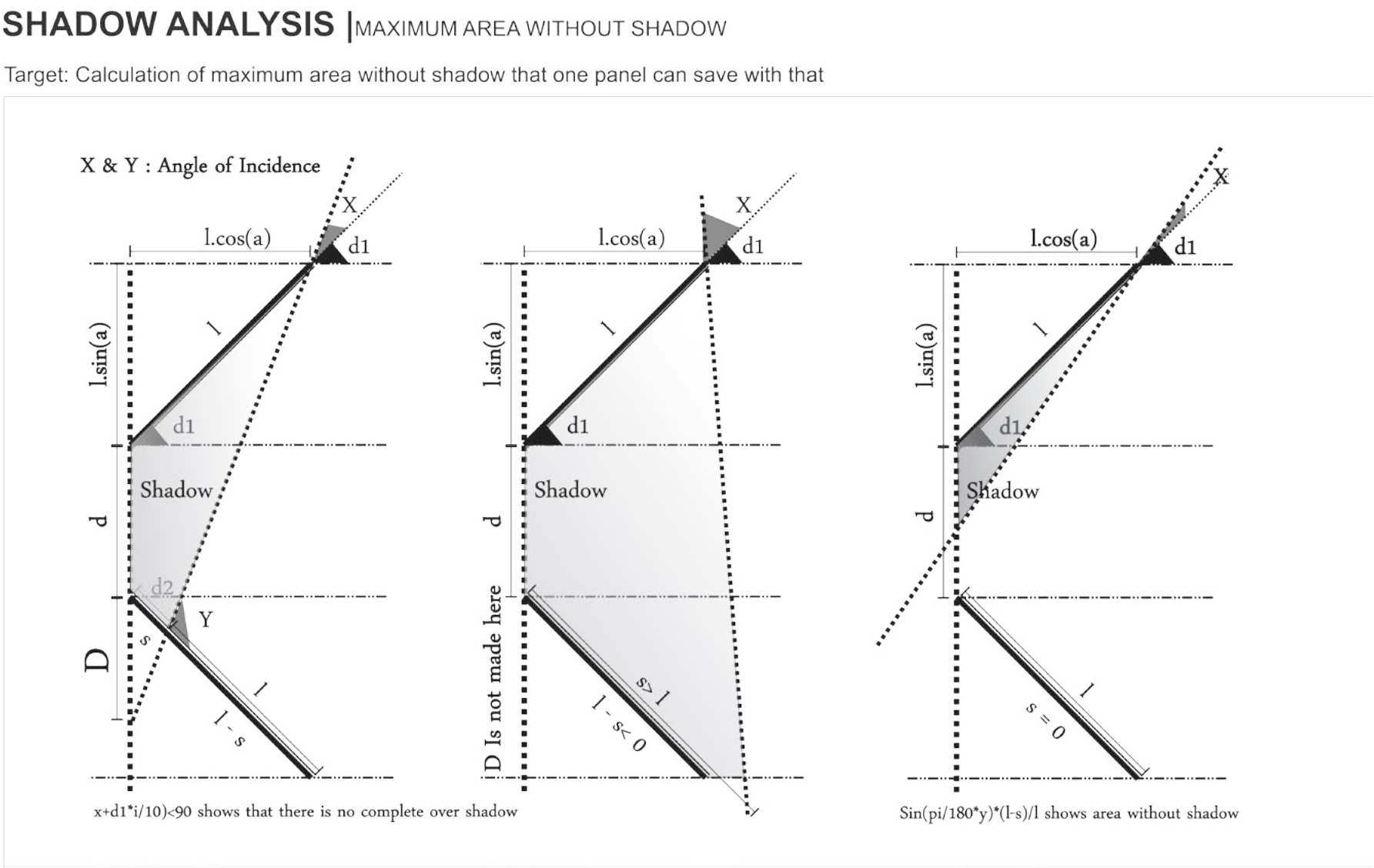


Figure21 Shadow Fish Former Prototypes Analysis

6. Former Analysis

Figure22 Shadow Fish Former Prototypes Application Rendering

6. Former Analysis

Figure22 Shadow Fish Former Prototypes Application Rendering

References

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