A Tangible Music Visualizer

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ABSTRACT

We designed and prototyped a tangible music visualizer. It consists of a set of internally lighted modular forms that physically deform in response to changes in sound. The modules also detect tactile pressure, enabling the system to double as an input platform. We demonstrate materials and construction methods for a durable and replicable prototype.

Author Keywords
Music Visualization, Computational Art, Expressive Interface, Tangible Interface

ACM Classification Keywords
J.5 Arts and Humanities (Arts, Fine and Performing, Music)
H5.2. Haptic I/O
H.5.1 Multimedia Information Systems (audio I/O, augmented realities)
H.5.5 Sound and Music Computing

General Terms
Design, Music, Art, Tangible

INTRODUCTION

Music and motion are connected in art forms as old as dance and musical performance. Sounds and images are perceptually linked. Human brains constantly try to find interesting connections between what they see and what they hear. Music visualization technology attempts to augment the experience of listening to music with synthetically generated imagery. Most existing visualizers are screen-bound or based on changes in illumination of static objects. Inspired by the way living things react to stimuli, we aimed to create a stronger perceptual impression by designing a visualizer that changes its physical shape in response to sound. Our prototype consists of a set of radially symmetrical flexible forms that resemble bioluminescent sea life or fungi, reflecting the concept's biomimetic origin.

PROTOYPE DESIGN GOALS

1. Build enough modules to cover a large surface and give the visual impression of a colony of lifeforms.

2. Design at least three different module types or sizes, to add to the biomorphic aesthetic and delineate different frequency ranges.

3. Each module should have independently controllable RGB lighting to allow illumination that complements its movement.

4. Touch sensors in each module will allow them to be used as input devices, perhaps programmed to produce responsive changes in lighting or act as musical instruments.

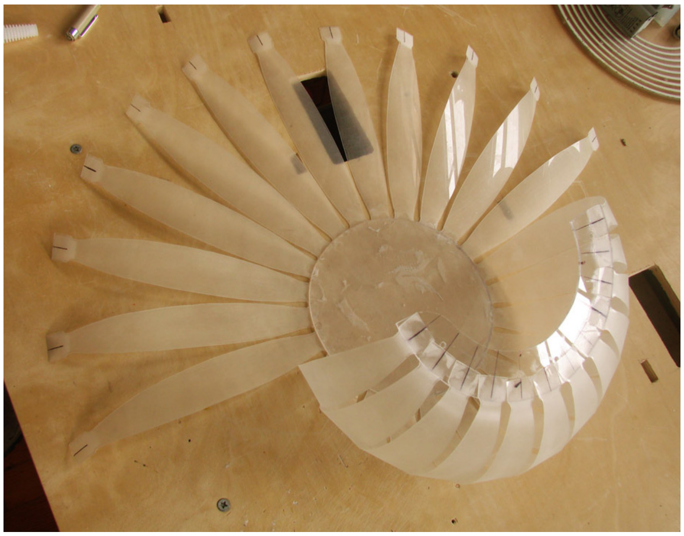
5. The system should be self-contained, with no attachments to audio lines, external amplifiers, or computers.

TECHNICAL SUMMARY

Each module has an independently controllable actuator to induce deformation, internal fully controllable RGBW lighting, and an IR pressure sensor to detect deformation by an externally applied force. A central control board located in one of the larger modules receives and processes audio signals (including ambient sound from an internal microphone) and sends control data to the modules through a set of reconfigurable cables.

Housings

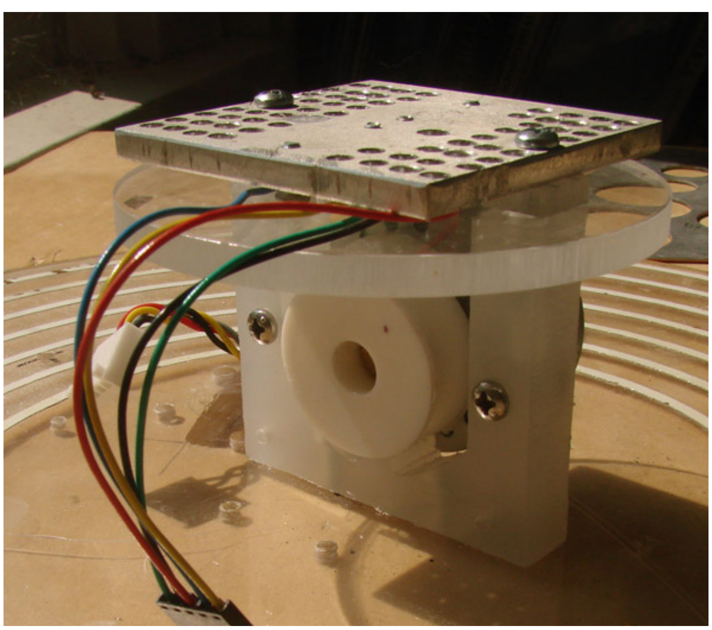
The deformable exteriors of the modules define the prototype's aesthetics. To enable lifelike deformation under the force of a small actuator, a highly flexible material was required. Castable silicone proved too costly and time-consuming to fabricate on the required scale. Instead, resilient mylar sheeting was laser cut into shapes that could be bent into hollow spheroids. Vertical rib-like openings allow the forms to expand under pressure. Cyanoacrylate glue was used to attach the top of each housing to a rigid plastic (PETG) disc, and the ends of the 'fins' that make up the sides of the modules were glued to a pair of half-rings. These are attached to the modules' rigid PETG bases using removable machine screws.



Actuation

The desired motion required a linear actuator capable of 5 cm of displacement in 300 ms or less. After experimenting with several actuators, including solenoids, muscle wire, and linear gearmotors removed from surplus DVD drives, we found stepper motors with pulleys attached to be the best option. Lengths of monofilament were attached to the pulley wheels and to the top disks of the housings. When a stepper turns, the monofilament wraps around the wheel and pulls the top of the housing down. The use of steppers allows the motion to be finely controlled in software.

The motors attach to the base plates with simple mounting hardware fabricated from polypropylene. Each pulley wheel has a protrusion that catches a stop on the mounting assembly, preventing it from pulling too far in case of a missed step. The lighting assembly on top of each motor mount contains a 3W white LED and a 3W RGB LED fit into a light-spreading acrylic disc. A polyethylene sleeve allows the monofilament to pass through the LED heat sink with minimal friction and attach to the top of the housing.



Actuation and lighting assembly

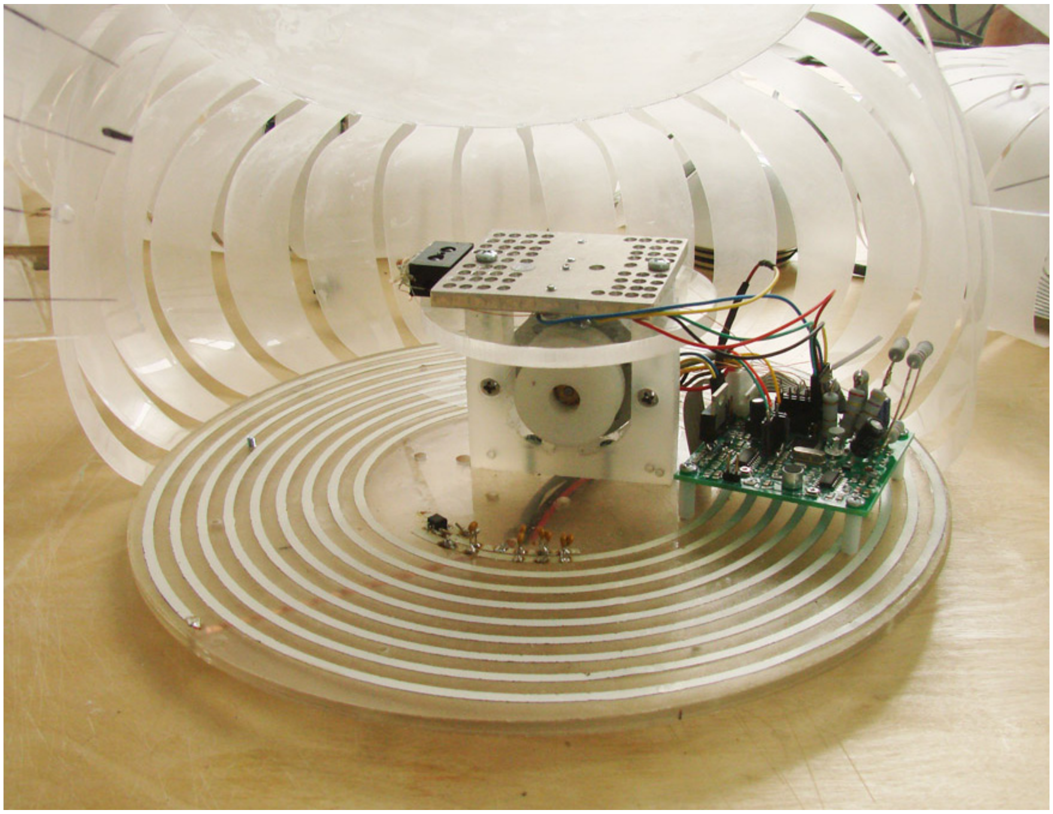
Touch Sensing

The pulley-based actuation scheme allows the modules to be compressed by externally applied force, so we chose a touch sensing system that simply senses the height of the top of the housing. Proximity sensors with a range of 0-6 cm were required. We found that an infrared LED placed at an angle near a 5mm IR phototransistor gave enough accuracy for the application. Blocks of IR-opaque black ABS were machined with angled holes to hold the parts in position. To reduce spurious signals from ambient light, an algorithm was developed that alternately records the phototransistor’s output voltage with the IR LED on and off, and returns the difference between the two values. This method proved to maintain reliability even in direct sunlight.

Power and Data Transmission

It was apparent early in the prototyping process that connecting power and data cables to each module would compromise the portability of the system and the flexibility of the module layout. This led to an investigation of wireless power and data transfer, detailed here. In the interest of simplicity, a wired system powered by an ATX supply was used for this prototype. The 12V rail powers the motors and logic, and the 5V rail supplies the LEDs. Power cables from each module connect to headers at the power supply. At peak, the system consumes less than 150 watts.

To make the system easy to expand, and to maintain compatibility with possible wireless control, we decided to use a serial packet-based control system. Each module has an internal processor that translates serial data from the central controller and sends back data from the IR sensors. PCBs were designed in Eagle and fabricated by Advanced Circuits. Lengths of repurposed telephone cable with removable headers connect the modules to the main controller located in one of the larger modules.

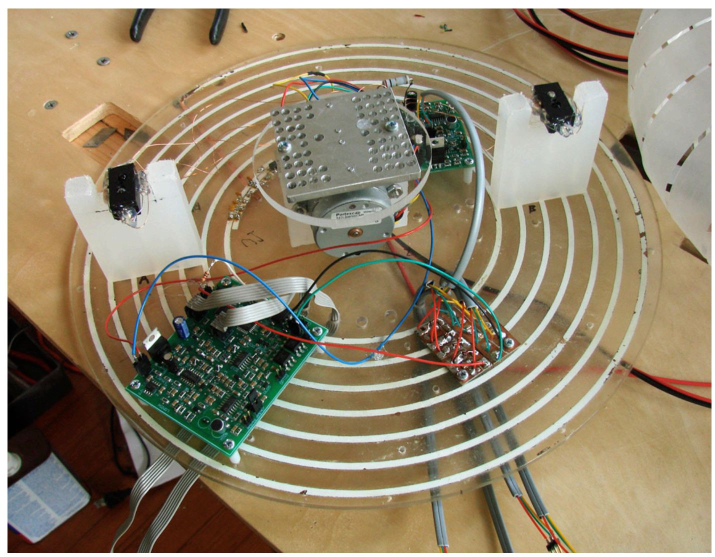


A complete module assembly. The IR proximity sensor is visible to the left of the LED heat sink plate located above the motor mount. The white spirals visible in the images are receiving coils remaining from the wireless power research.

The Controller

To minimize software complexity, we chose a hybrid analog-digital signal processing topology. A pair of ATmega168 microprocessors analyzes the output of 7 op-amp based audio bandpass filters. The filters receive an external audio signal or the output of a built-in amplified microphone.

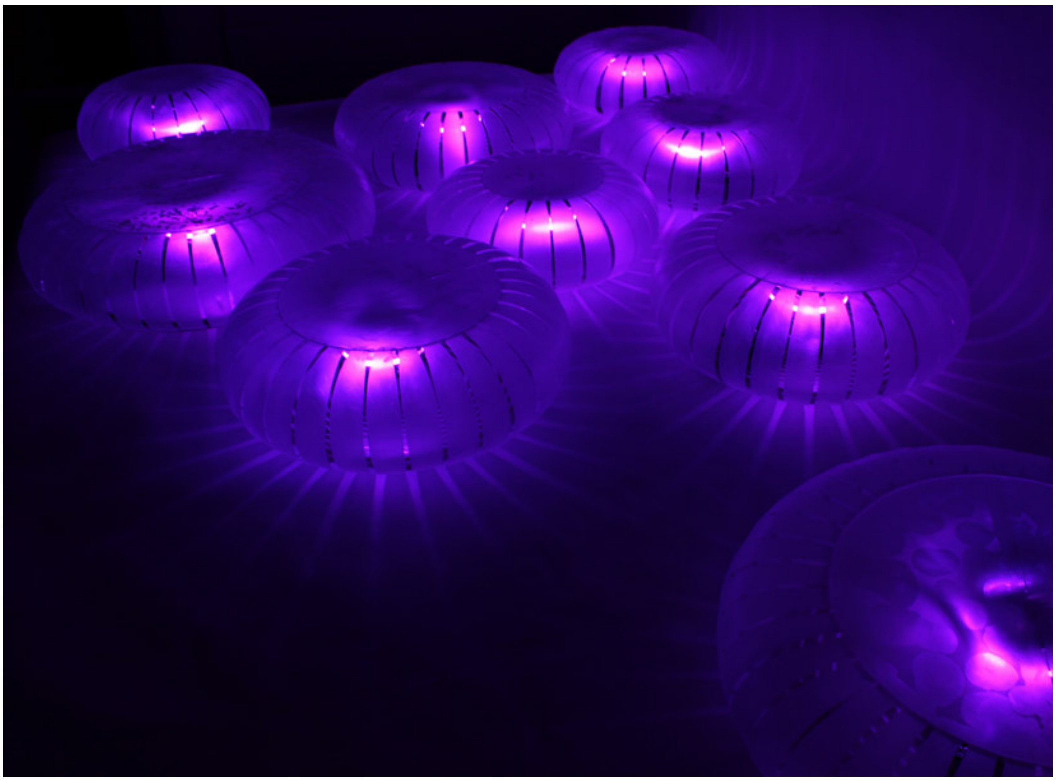
One of the processors is dedicated to detecting impulse in the incoming sound. It maintains two moving averages of each frequency band, one from the past 100-200 ms and another from the past 5-10 ms. The differences between the two values are used as the main indicators of perceivable impulse. The second processor receives the impulse data, generates lighting data for the LEDs, and sends the serial packets. With the current 9 units and a 19200 bit/s bitrate, the control data is refreshed at 35 Hz. The current code contains a number of different functional modes, each selectable by briefly pressing down on one of the modules.



The controller PCB mounted to a module's base plate.

TESTING

We tested the system's response to a variety of types of sound and music through its internal microphone. Video of the results can be viewed here. With the current control software, percussion-driven and electronic music generates the most interesting responses. User reactions to small-scale demos have been positive. In coming months, we plan to test the concept's appeal to a wider audience.



FUTURE WORK

With minor alterations to its electronics, this prototype could be controlled by a desktop-type computer. The superior processing power would allow a much larger space of responses and interactions to be explored.

We're interested in opportunities to build a larger system as an interactive installation, or to integrate the concept into a consumer product like a speaker system.