**LightLeaves**: computer controlled kinetic reflection hologram installation and a brief discussion of earlier work

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Abstract. *LightLeaves* is an installation combining leaf shaped, white light reflection holograms of landscape images with a special kinetic lighting device that houses a lamp and moving leaf shaped masks. The masks are controlled by an Arduino microcontroller and servomotors that position the masks in front of the illumination source of the holograms. The work is the most recent in a long series of landscapes that combine multi-hologram installations with computer controlled devices that play with the motion of the holograms, the light, sound or other elements in the work.

*LightLeaves* was first exhibited at the Peabody Essex Museum in Salem, Massachusetts in a show titled “Eye Spy: Playing with Perception”.

![Image of LightLeaves installation](image)

**Figure 1**  
LightLeaves 2012

To explore new ways to create the most realistic images of the natural world, to capture the light falling on a subject, record it full color with motion and sound in three dimensions, and instantly transmit the images around the planet. Holography and computer generated imagery are the latest scientific display technologies with the potential to realize this, and artists have helped shaped the development of all these technologies & mediums.
1. INTRODUCTION

My work in holography is concerned with using nature as a primary subject and using multiple image installations as the form. Adding a kinetic element for hologram motion or lighting effect, usually controlled via a computer, creates an ambient feeling of the natural world. In a previous paper [1], I talked about using landscapes as a subject, and explored my interest in juxtaposing technology with nature, as well as bringing attention to the concerns many artists have about environmental issues, and the creation of art works to heighten an awareness of the damaging changes taking place on our planet. In this paper I would like to talk about the creation of LightLeaves and comment on the application of computer controllers to create motion in my work. I have used a variety of control systems in previous works over the years, and now the electronics are much smaller, cheaper, and accessible for everyone to use.

My interest in creating motion, sound, and lighting effects in my work in holography, has roots in my earlier work in film and video, and parallels (but in a different way) the quest to create holographic electronic moving images.

2. BACKGROUND

When I began working on LightLeaves and other recent works, LightRain (I and II), I considered the fact that in creating installations that express a connection to nature and a concern for the environment, with the awareness that these works do themselves have an environmental “footprint”; using precious resources to create the holograms which in turn put chemicals and pollutants, etc. back into the ecosystem. I also became aware of the amount of materials used in holography, when I inventoried, assessed, and catalogued forty years of research, done by Dr. Stephen Benton and his students and colleagues at the former Polaroid Corp. and MIT’s Spatial Imaging Group. There was a near four to one ratio in holographic plate use over the years, which was similar to my own lab habits. I made many multiple hologram installations, and produced many extra “test” plates to achieve a single usable one, so I decided to create a new work by using fragments of the useable parts of already existing older work. The pioneer video artist Nam June Paik, with whom I had the privilege of working in video, often recycled older videotape imagery into newer sculptural forms in his large TV installation works. This idea influenced my holography installation work. Paik was a personal mentor and master of mechanical invention and form, and a great influence on many artists.

3. LIGHTLEAVES

LightLeaves is a white light reflection hologram installation, made up of leaf-shaped reflection holograms of images of plants, flowers, trees and leaves; from both real and fabricated landscape subjects. Many of the master holograms for the work were produced using a pulsed laser, during an artist-in residency at The Center for Holographic Arts in New York. Other masters and all transfers were produced in my lab, ACME Holography, in Somerville MA. The holograms are mounted at different depths with threaded rods onto six, 9”x9” black lacquered panels. The panels are approximately 1 ½” deep, mounted off the wall and the holograms are mounted one to four inches out from the panel surface.
The installation is illuminated by a special effects lighting device that houses sensors, motors, a lamp, and leaf shaped light “blockers” that move across the work in front of the light, controlled by a small microprocessor. The motion of the light blocking elements responds through a sensor to the temperature in the gallery where the work is displayed; causing the motors to move the masks faster when the temperature is higher.

3.1 Out of the Frame - Off the Wall

The holograms are laminated to plastic of different opacities and then cut from stencils created from actual maple leaves, for a one to one size ratio. They are mounted to the panels with half inch spacing between each panel. Some of the holograms were mounted on clear plastic, some on fifty percent opaque plastic and some on solid black (Figure 4). There is an interesting play of light across the different substrates, at certain angles, and outside the illumination areas. The various imaging depths (in the z-axis) of the holograms, interacts with the material substrate and the other hologram planes, to create an awareness of the 3-D flow across the images. The illumination device with rippling leaf shadows creates a subtle effect of simulated sunlight and wind moving across the three-dimensional leaf layers of three-dimensional imagery.

3.2 Illumination Device 1

When LightLeaves was first installed at The Peabody Essex Museum (Salem, MA), the location of the work in the gallery was under a soffett, so I had to design and construct the illumination device specifically to work in that space (Figure 5). The light was fixed directly above the work, pointed into the space towards the device, and then directed with a mirror about twelve feet away to light the work. The device was built into a box, approximately twelve inches wide, by fourteen inches high, by ten inches deep, with the mirror mounted inside to produce the correct illumination angle. The box also contained an Arduino microcontroller attached to two motors and a sensor. The Museum asked that I camoulage the device into the Museum space, so the box was painted to match the gallery, and was placed and tuned for the correct illumination position, and then glued onto the ceiling above and in front of the hologram. Two lightweight wires with small aluminum leaf shaped blockers were mounted onto the motors controlled by the Arduino, and programmed to simulate jittery wind motion. A temperature sensor was also attached to the Arduino to control the speed of the motors. When the sensors detected a rise in the temperature in the gallery, the Arduino program made the motors move faster and so the leaves “blew” a little more wildly. I don’t know if the viewers sensed the difference, it is a very subtle effect.

3.3 Illumination Device 2

I designed a new lighting device for the newer version of LightLeaves for the ISDH exhibit in 2012, which I built out of aluminum framing (Figure 6) since the work would be lit traditionally for reflection holograms—from above and in front of the work. I bought a PAR 36 fixture and lamp for the best illumination distance to the holograms, and built an aluminum box around it with holders for the motors and leaf blockers, now directly in front of the lamp, but at a distance of approximately ten inches for one motor, and sixteen inches for the other (Figure 7). The Arduino microcontroller, the same used in the PEM show, was attached to the back of the housing away from the lamp. I also added plastic baffles to block light from spilling into the gallery space. Although the device
was not built with a milling machine or CAD fabrication equipment, it proved to be a very stable platform for the motor control and the distance from the leaf blockers to light can be controlled pretty precisely. The programing for the Arduino controller was done by Dave and Cody Chen, for the first version of LightLeaves and modified only slightly for version two.

4. LIGHTLEAVES CONTROLLER

The Arduino is an open-source electronics prototyping tool for integrating sensors with motor-control and is a perfect system for creating interactive installations. The baseboard includes a microcontroller, 14 digital input/output pins, 6 analog inputs, USB connector and a power jack. The free Arduino software includes a “Servo” library that uses 2 of the available digital outputs to generate the PWM signals needed to control the inexpensive off-the-shelf servomotors that we used for LightLeaves. The LightLeaves installation also uses a simple temperature sensor through one of the analog inputs to control the speed and direction of motion for the leaves.

The basic Arduino board is very inexpensive (less than $50) while the Vex servomotors we used on each side of the frame were about $20 each. The Arduino software is available as a free download and runs on Windows, Mac and Linux. The development environment is very user-friendly and lets you easily download compiled firmware through the USB port of your computer and see debugging output from the board.

The Arduino programming language is based on Wiring and is implemented in C/C++; and is very similar to the Processing language invented at MIT. The language includes all the expected control and arithmetic operators, data types and ability to define sub-routines. The program we wrote for LightLeaves is about 150 lines long and includes routines for moving each branch in a specific direction for a set distance. To simulate leaves moving in a changing breeze we tied in the temperature controller with a random number generator to create an environmentally sensitive affect.

5. LIGHTRAIN CONTROLLER

We used a different motion control system for the holograms in a previous installation, LightRain (figure 9), which is a hanging kinetic sculpture of over eighty narrow ‘rainbow’ transmission hologram shards of landscape images. The narrow holograms are attached with filament and suspended from a housing device containing both motion-capable and stationary hologram holders. The motion holograms are controlled by a VEX robotic microprocessor, which is programmed to operate two motors and using a variety of sensors to run simple vertical movements of the hologram shards. The vertical movements of the hologram display “jewel like” shimmering effects, viewable with “water like” reflections below and behind the sculpture. Like the Arduino, the Vex microcontroller also provides a simple, easy to program platform for creating a broad range of motor control applications with sensor inputs. But because it is geared to “off the shelf” use in the school education market, the Vex is considerably more expensive—with Starter Kits in the $400 range. The standard kit comes with quite a few components including the microcontroller, motors,
servomotors, optical encoders, light sensors, ultra sound distance sensors, gearbox components and “Erector Set” type metal motor mounts and frameworks for assembling small custom structures.

For LightRain (Figure 10) we set up two independently controlled banks of holograms attached to 30-inch wooden dowels, separated by about six inches. Each bank had its own independent motor and spun the dowel with a gear ratio reduction of about four-to-one. Each bank also had its own optical encoder to measure the number of revolutions that the rod would turn. The holograms were then attached with filament onto the rods as well as stationary hooks.

We started with a simple control strategy of cumulating the count from the encoders to measure the total distance travelled, but we found very quickly that this number was not accurate due to mechanical backlash and play in the system. Thus, to avoid wrapping the holograms around the wooden axle, we had to add a separate switch to each bank to tell us when the filaments were close to their extents.

6. FUTURE GARDENS CONTROLLER

The Future Gardens holographic installation [2] (Figure 11) was my first work using computers to control lighting and sound. Working with composer David Atherton, we set up a MIDI music mixing board to program a theatrical lighting grid with the cues triggered by David’s music composition. The composition was approximately 12 minutes long and there were individual lighting cues for over forty holograms. The installation was seventeen feet long by ten feet high by seven feet deep. The images are of traditional western landscape imagery: combined with traditional eastern landscape elements inspired by a visit to Japanese gardens in Kyoto.

The sound mixing board computer program was limited to on/off and any rate of dimming the lights but it could be run by the music cues, so in that way the sound and lighting were in perfect sync. The forty individually controlled lights had to be run through expensive lighting dimmer packs, made more for the 500Watt or 1K to 3K lighting fixtures used in theater productions.

7. LIGHTFOREST AND FUTURE GARDENS CONTROLLER

LightForest: the holographic rain forest, [3] (Figure 12) installation was even more ambitious with the installation of well over two-hundred 12”x16” holograms of rain forest plants, leaves, tree trunks and flowers. Multiple white light rainbow transmission holograms—from fifty to sixty unique masters—were created, laminated, and mounted behind the walls of a specially designed space. It was a room within a room, within a Museum, with the illumination hidden behind the walls, above the ceiling, and from below a false floor.

LightForest was a Star Trek ‘holodeck’ inspired space, with the idea to hide the illumination sources, as best as possible, from the viewer. The lighting for the holograms was controlled using a MAC MIDI system that extended what was done for Future Gardens. One idea for the water image holograms installed in the floor was to have the computer controlled lighting ‘twinkle’ across the holograms the way sunlight dances across a lake or pond.
Back in the late 1990’s when planning the sensors and lighting control that would be used for LightForest, MIDI was the most widely used protocol by artists working with physical interfaces, computers, lighting and synthesizers. Inspired by early work of Hiroshi Ishi’s Tangible Media Group at the Media Lab, we programmed the lighting for LightForest in the MAX graphical programming environment developed at IRCAM in France.

Max lets you easily “patch” together lighting and sampled sounds with sensor inputs, firing events from a preset musical track and perform changes on the fly. We used proximity and sound sensors as additional triggers for interactive lighting effects and tried to create a unified experience as groups of people explored the LightForest space.

We had to invest a hefty amount into the LightForest control system; $500 for the MAX software, a small MIDI controller, 2 light banks for high-voltage lamps, and a myriad of homemade sensors. When compared to the cost and effort needed for LightLeaves, the difference is amazing.

Look deep, deep, deep into nature and then you will understand everything. Albert Einstein

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