Lenticular Waterwheels: Simultaneous Kinetic and Embedded Animation

Scott Hessels
School of Creative Media
City University of Hong Kong
18 Tat Hong Avenue
Kowloon Tong, Hong Kong SAR
shessels@cityu.edu.hk

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Scott Hessels

ABSTRACT

After decades as a novelty, lenticular technology has resurfaced in compelling large-scale projects. Without any required energy, the medium offers stereography without glasses and frame animation without electronics. A kinetic artwork installed in a remote river in the French mountains broke from the technology's previous restrictions of static and flat display, recalculated the print mathematics for a curved surface, and explored narrative structures for a moving image on a moving display. This paper documents how the sculpture used custom steel fabrication, site-specific energy, and revised lens calculation to present a previously unexplored hybrid of animation.

In 2016, I was commissioned to create an outdoor kinetic sculpture for Sancy Horizons Art+Nature, an annual competition in central France in which large-scale artworks are placed throughout the Auvergne volcanic range and visited by hikers and tourists during the summer. The site provided for this work was a river near the village of Égliseneuve-d'Entraigues, about two hours from Clermont-Ferrand, France (latitude: 02°50'12.3" E, longitude: 45°26'31.7" N).

I conceived large-format lenticular prints mounted onto rotating cylinders to be turned by waterwheels dipped into the mountain river's flow. Inside each cylinder, I designed simple lighting systems to use the river's flow as power to light the images and area around the installation. As the river's flow turned the waterwheels, glowing animations of patterns would continuously loop (Figure 1).

While the machines are seemingly simple, the sculpture presented concurrent animation in both content and surface as a result of custom steel fabrication and plastic lens printing. The curvature of the screen's surface required a revised calculation for the visual effect, and the kinesis of the display surface forced a rethinking of narrative structure. The complete system included the steel construction of the player machine, the revised calculations of the surface print, the concept and design of the animation content, and the installation at the site. Together, the components revealed a previously unexplored variation in lenticular technology.

Background

The work was the sixth in a series of kinetic public sculptures that I created under the theme of sustainable cinema. Each sculpture uses natural forces inherent in a site as the energy source to power a simple animation. The forces have included water, wind, tides, pedal-power, and sunlight; the animation has utilized device technologies including zoetropes, praxinoscopes, phenakistoscopes, shadow plays, and lenticulars. By referencing the histories of both film and industrialization, these sculptures are meant to encourage a possible future of more environmentally responsible media by presenting an alternative history of moving image power usage.

Additionally, in being designed for public spaces, they are meant to stimulate general awareness

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Figure 1. A digital painting of the proposed design for *Sustainable Cinema No. 6: Lenticular Waterwheels*, 2016. (© Scott Hessels. Photo: Scott Hessels.)

about alternative clean energy sources. The moving images first entertain and then inform the public about the fundamentals of sustainable design. The sculptures take the abstract principles of renewable energy and makes them tangible and accessible.

Previous sculptures in the series have been presented at the Gerald R. Ford Presidential Museum, Ars Electronica, The Museum of Contemporary Art Taipei, and the Los Angeles Convention Center as part of SIGGRAPH 2012, among others.

Lenticular History

Lenticulars were selected for the commission to promote a less-familiar image trajectory in French history. As early as 1692, French painter Gaspar Antoine de Bois-Clair created optical art that changed when viewed from different angles. His double portrait of Prince Frederik IV and royal sister Sophie Hedevig is a confused amalgam when viewed from the front. However, both subjects become individual when the viewer passes, seeing one image from the right and the other from the left.

The foundation of lenticular printing, a plate of many very small lenses, was first outlined in 1908 by French physicist Gabriel Lippmann (better known for his Nobel Prize in Physics for color photography) [1]. The actual manufacture of this lens was not possible until many years later as molded plastics development moved forward. 3D lenticular photography was greatly advanced by French camera designer, inventor, and photographer Maurice Bonnet. His radical and original imaging techniques are still in use today, and scanning lens cameras are still

referred to as "Bonnet style" [2]. Bonnet is a transdisciplinary icon in image development as someone who developed the technique, the system, and the content. As an academic he advanced knowledge, as a scientist he transformed an industry, and as an artist he produced works of great beauty.

As other imaging technologies for animation and 3D were introduced, lenticular printing became increasingly novelty-based and kitsch. However, the recent artwork *Beyond* at Schiphol Airport by Studio Roosegaarde [3] shows its dramatic potential in large-scale 3D displays, and George Legrady's *Night and Day* [4] series proves the technology also has the potential for a unique metaphoric layering of time and place.

Lenticular Technology

Lenticular printing slices two or more different images that are then spliced back together into a single image and placed behind a sheet of plastic molded with a series of thin lenses. Frames of animation can be interlaced to create a motion effect, off-set images can be used for a 3D effect, or completely different images can be alternated. The lenses must be accurately aligned to the interlaces of the images, which results in light refracting off each slice in a different direction. This slight variation in the direction of light creates a stereoscopic effect when viewed directly but can also create animation if the print or viewer is moved. Stereoscopy is only possible with horizontal, side-to-side movement. Other effects are possible through vertical movement, including motion, morphing, and a range of pseudo camera movements. I designed the waterwheels to take advantage of the range of options available with top-to-bottom movement.

The Player: Animation Powered by Natural Energy

The waterwheels and system to hold the prints were designed and fabricated in a welding shop in Hong Kong. The water's depth was calculated to 15–40cm and a system in the mounts allowed for adjustment for best flow. Most parts were made of stainless steel. Low-speed generators were purchased from a discount website in mainland China and the waterwheel rotation was converted to low-voltage electricity capable of powering a single row of LED lights running along the internal axle. As the lenticulars would be lit from inside, clear plastic tubing was used to support the print to allow light to pass through with minimal shadow (Figure 2). Once tested in Hong Kong, the machines were dismantled, shipped to Clermont-Ferrand, and received by the architecture school there. Students in the school were recruited to assist with the assembly and installation in the river.

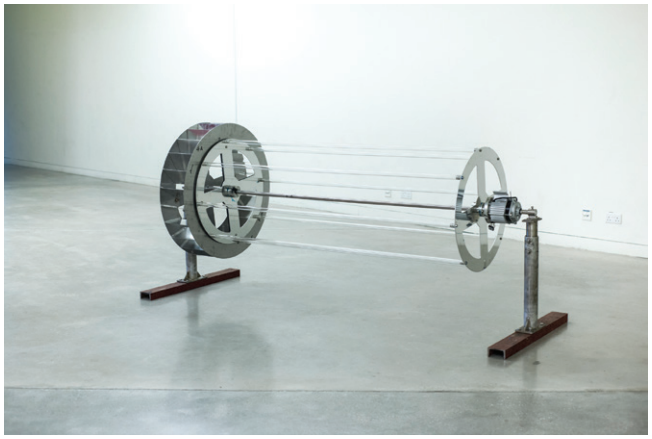

Figure 2. Waterwheel machines without prints. *Sustainable Cinema No. 6: Lenticular Waterwheels*, 2016. (© Scott Hessels. Photo: Scott Hessels.)

The Content: A Gif Riding on a Gif

Depending on river flow, the cylinders would rotate approximately once every five seconds. The image, two plastic prints measuring 180cm × 120cm, would be stitched to form a viewing surface of 180cm × 240cm. The "top" and the "bottom" of the print would line up so that the rotation caused by the river would create a five-second loop of animation. Within the rotation print are five "flips"—five interlaced frames of animation

that are sliced so that each becomes visible when the curved lens moves. The final effect is a moving image looping through five frames of animation that appear and pass by every five seconds of rotation.

A moving image on a moving screen has become culturally commonplace as mobile phones are now common display systems for cinema. Dual-image kinesis is often discussed as a hybrid of moving images, a post-cinema development created by digitization [5]. The static, fixed viewing position of cinema has expanded and kinetic screens, whether intentionally designed as such or simply transported in one's pocket, are all around. Screen mobility has affected cinema's form by favoring shorter duration [6]. Despite the apparently low-tech design of the waterwheels, the systems offered an opportunity to explore the use of retrograde technologies to reconsider both shorter form and also narrative structure.

Narrative Structures for Kinetic Sculpture

The original design called for animated patterns due to the complexity of simultaneous movements. However, I explored the challenge of dual animation, both image and surface, further when I received the commission. I developed two different stories, each in the form of five large animation panels with the understanding that the focused viewing area would be approximately 60cm × 180cm when moving down the panel horizontally.

One story idea, "Country Noir," was to place the five cylinders in the river to form a larger tableau. The most distant machine depicted a night sky flashing with lightning; the next machine contained animations of gothic-style tangles of trees and crows; the next machine showed bats in flight; and finally the cylinder nearest the viewer was an animation of a woman holding a torch continuously running down a dark stone staircase. When viewed together from a bridge over the river, the five animations would combine the character animation in five-frame loops with background animation rotating past to form one giant "image" of a haunted night in the highlands.

However, designing and working in Hong Kong for a site in the French mountains presented so many unknowns that a compromise between pattern and photorealism was more prudent. The materials and forces within the site and the sculpture's construction in China provided the inspiration to visualize *Wu Xing*, the traditional Chinese belief in the five forces of nature—water, earth, plants, fire, and metal—which must be kept in balance. The philosophy is not concerned with the elements themselves, but with the relationships between them. Five-frame images of stones falling, flowers opening, gears turning, fire burning, and water bubbling were created with the top and bottom lining up to make the loop seamless during rotation (Figure 3).

Site Experience

The work was installed in June 2016. The waterwheels were placed downstream from a small wooden bridge that allowed for viewing all five simultaneously. A small path along the river's edge made it possible for visitors to walk alongside the installation, while the depth of the river made closer inspection also possible (Figure 4). The combined display surface and distribution throughout the river made the artwork one of the largest lenticular displays in the history of the medium.

The river is a high-altitude mountain stream flowing through a valley between two volcanic ranges. Two days prior to the exhibition opening, a violent mountain storm passed through the region, raising water levels as much as 50cm in high force. The plastic rods supporting the lenticular prints snapped and the sheets were ripped from the machines, mangling the steel

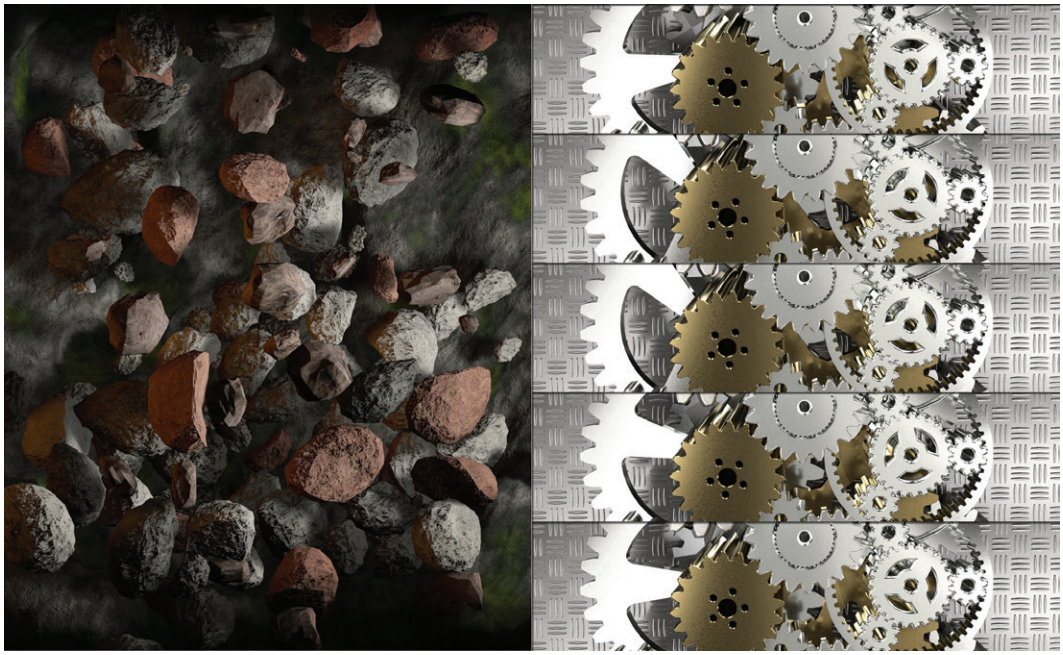

Figure 3. Single frame of earth animation, 180cm x 240cm, and sliced frame of metal animation representing five frames. *Sustainable Cinema No. 6: Lenticular Waterwheels*, 2016. (© Scott Hessels. Photo: Scott Hessels.)

Figure 4. Installation of *Sustainable Cinema No. 6: Lenticular Waterwheels*, 2016, in Auvergne, France. (© Scott Hessels. Photo: Scott Hessels.)

support wheels. All loose metal and rod fragments were recovered, although, strangely, no fragments of plastic from the lenticular sheets could be found. It was hypothesized that they had been stolen after breaking loose. However, the evening prior to the opening they were found intact under 50cm of mud at the base of a large waterfall downstream. The lenticulars were recovered from the icy water and carried upstream. For the opening, the machines with reattached lenticular prints were displayed along the riverside, allowing guests to rotate the machines themselves and view the resulting animation.

New supporting rods to hold the lenticulars were fabricated from steel and the machines were returned to the river. However, violent weather conditions continued to damage the systems through the duration of the exhibition. The electrical systems never recovered from the initial storm and a heavy hailstorm, with ice as large as 5cm in diameter, pounded the structures in early July. Direct sunlight softened and deformed one of the sheets when its rotation was stalled by a tree branch caught in the current. Evidence of direct hits from lightning were present in two of the prints in early August. The five machines were hobbled together until their removal from the site at the end of the exhibition in mid-September. They have since returned to Hong Kong and mechanical repairs and new animation are occurring for a revised presentation of the systems in another, less-difficult context.

Conclusion

When the difficulties regarding the site and subsequent damages to the artwork were relayed to colleagues in Hong Kong, there was a discussion regarding Wu Xing. Each force in Wu Xing can overpower another if the equilibrium is not correct. The philosophy posits that the five energies—fire, metal, earth, water, and wood—are of equal power and only imbalance can cause one to overcome the other. The artwork had proven one of the philosophy's core phases—water breaking metal. I had miscalculated not the flow of the river nor the strength of the steel, but simply the balance of the energies present.

The rapid development of moving image technologies and displays can make it difficult to understand the shifting ontology inherent in new forms. The sculpture simplified the complex relationship between movement and moving image and, due to the site, demonstrated the volatility of the relationship as well.

References and Notes

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