Crystal Zoetrope: New Visual Medium for Displaying 3D Animation

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Abstract

The authors have turned the Zoetrope, initially an optical toy from the pre-cinema era, into a three-dimensional (3D) animation display. "Crystal Zoetrope" is a new visual medium involving a glass disc with numerous engraved objects that displays a sophisticated 3D animation. It can be built in small sizes and even be embedded in everyday objects or environments. Using this new visual medium, the authors produced the 3D animation "Sea of Stars" that portrays the life cycle of planets in the universe.

Introduction

British mathematician William George Horner invented the modern Zoetrope in 1834. Back then, this simple device generated a dynamic two-dimensional (2D) animation that was enjoyed by people as an optical toy until the advent of film in the late 19th century [1]. Still, the Zoetrope can be found in contemporary museum stores inspiring artists on alternative ways to create moving images with low-tech materials.

Several artists, including Toshio Iwai [2], Gregory Barsamian [3], Stewart Dickson [4], and Eric Dyer [5], have improved the Zoetrope during the past three decades to display 3D animations. Moreover, the Ghibli museum currently exhibits a 3D Zoetrope called "Bouncing Totoro" [6], and Pixar Animation Studios have built another one, featuring characters from the movie *Toy Story* [7].

Why have some media artists tried to turn the pre-cinema toy into a 3D animation display or an animated sculpture? We assume that spectators feel a strong visual impact from a 3D Zoetrope that other traditional visual media fail to achieve. It seems to be attributed to the unusual physicality of the animation, which a series of static objects and synchronized strobe lights create. Usually, we see 3D animations through holograms or stereoscopic displays in a purely optical way. In contrast, 3D Zoetropes provide us with a spatial animation in a mechanical way. A succession of physical objects lit by strobe light utilizes the persistence of vision effects and generates an extraordinary animation of transforming 3D sculptures, which can barely be seen in the real world.

3D Zoetropes generally consist of hundreds of physical animation objects. Each object must be located at a particular position in space by means of supports. As a result, most 3D Zoetropes have a complicated structure and tend to be bulky. Such Zoetropes are fairly large, usually serving as an artistic installation in museums. Spectators must keep a distance from these Zoetropes to enjoy the animation.

When I took a trip to Beijing in 2003, I found a small "crystal" souvenir with translucent engraved objects in it as shown in Fig. 1a. Later, in 2007, I had a chance to visit the ICC Gallery in Tokyo where I encountered Barsamian's *Juggler*. These two unrelated events inspired me to come up with the concept of a new visual medium called "Crystal Zoetrope." What if a 3D Zoetrope is made up of engraved objects in a glass block? This way, even a tiny particle can be allocated at an exact position in space and can be part of a very sophisticated animated sculpture. Furthermore, the Zoetrope can be small enough to be embedded in everyday objects or the environment. As opposed to previous bulky 3D Zoetropes, its small size can provide spectators a more effective experience. We started the Crystal Zoetrope project to turn ordinary everyday things into playful objects with 3D animated sculptures.

Implementation

We applied the Sub-Surface Laser Engraving (SSLE) technique to produce a small but elaborate animation object for building a small 3D Zoetrope.

We started with designing hundreds of animation objects for each timeframe using 3D Studio Max and continued with allocating the objects along spiral curves by using Maya Embedded Language. The angular distance between every two juxtaposed animation objects measured 9 degrees, and the modeling data was engraved into a glass disc as shown in Fig. 1b using an SSLE apparatus. As in Fig. 1c, the glass block was mounted on a motor coaxially and it was encircled by twenty 5W power LEDs. We enclosed the Crystal Zoetrope in a table-like case that displayed animated sculptures through a tabletop window, as Fig. 1d shows. The motor rotated at 120RPM, while the power LEDs blinked at 80Hz. The animation objects in the glass disc were lit by the LED lights as they revolved around the axis of the motor.

The aforementioned 3D Zoetropes require darkness for spectators to enjoy a clear animation, as interfering ambient light might blur the animation or make objects merely appear to rotate around an axis. For this reason, spectators needed to enter a darkroom, where the Crystal Zoetrope installation could be experienced to its full potential. Our Zoetrope was small enough to be embedded in everyday objects or furniture, separating

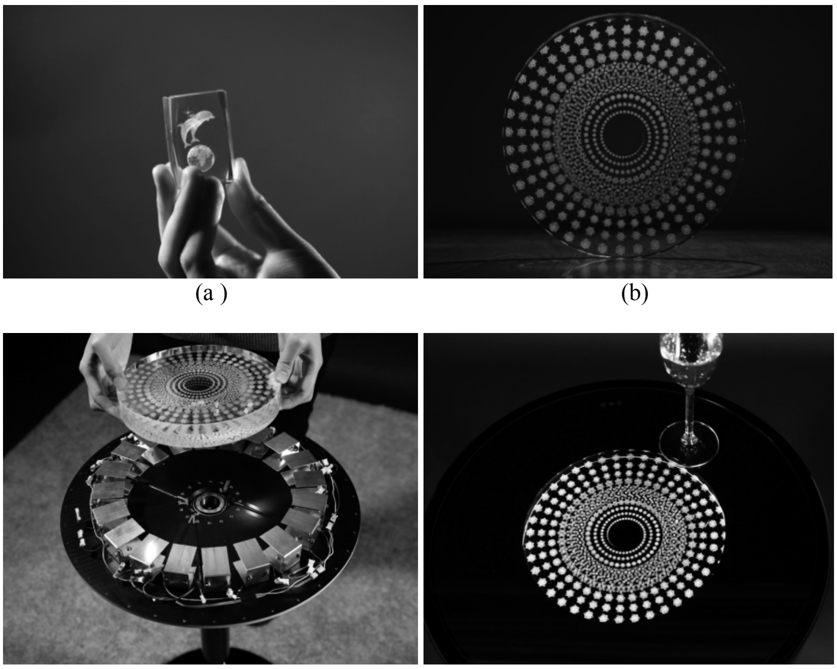

Fig. 1. (a) A glass block with engraved objects. (b) A glass disc with engraved animation objects. (c) The inside of a Crystal Zoetrope table. (d) The appearance of the Crystal Zoetrope table. (©Woohun Lee and JinHa Seong. Photo © Whan Oh Sung.)

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spectators from the Zoetrope's space. As a result, we enclosed the Crystal Zoetrope in a lightproof casing similar to that of a camera obscura. The casing was equipped with a window for spectators to see inside. The window was covered with a thin film that, to some extent, cut off ambient light from the outside to enhance the spectators' vision of the LED-lit animated objects.

The "Crystal Zoetrope Table" resembles ordinary furniture found in many pubs. We imagined that people might use it to place their drinks on, while gathering around it and having conversations. As people usually interact with a table physically, they might even enjoy touching it, seeing the small animated objects inside. We incorporated a touch interface into the table to provide spectators with a communication channel to the animated objects. People can control the direction, speed, or brightness of the 3D animation just by stroking the surface of the table. This minimal interactivity helps people to interact with and enjoy the animation more deeply.

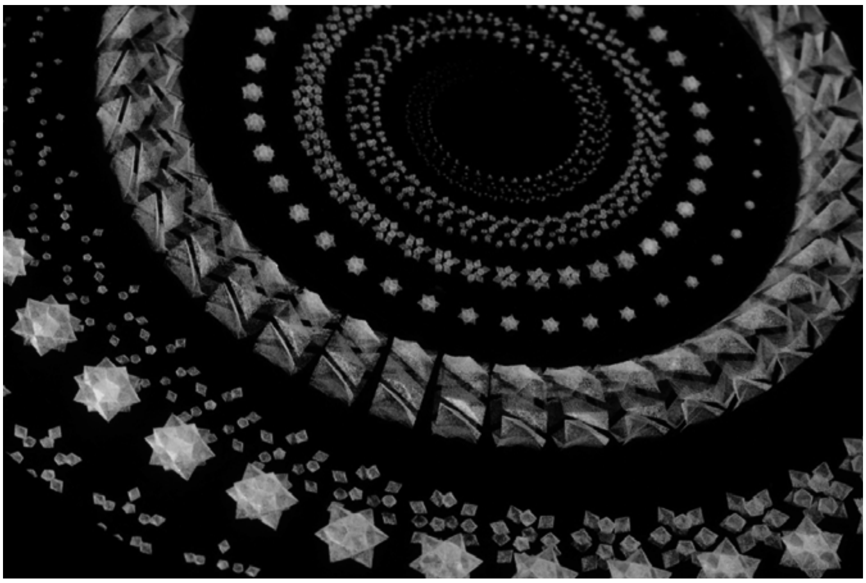
Exhibition

Based on this physical configuration, we produced the 3D animation "Sea of Stars," depicting the lifecycle of planets in the universe. The birth and death of stars is perpetual in the "Crystal Zoetrope Table."

The stars are categorized into two groups. One exists in the inner orbit of the space, whereas the other belongs to the outer orbit. In between the two orbits, there is a torus of small particles similar to Saturn's ring. As stars mature, they bounce from the outer orbit and move towards the center of the universe to burst back into particles. This star debris passes the in-between world and is resurrected as new stars in the inner orbit. Stars are born from extremely small particles in the inner orbit and grow bigger, while moving centripetally. Mature stars then explode like fireworks and disappear towards the center of the universe as shown in Fig. 2. The animation of one star lasts only 1.5 seconds and 2 seconds, respectively, in the outer and inner orbits. We tried to portray the eternal lifecycle of the universe within the limited time and space.

We exhibited the Crystal Zoetrope at SIGGRAPH 2009 Emerging Technologies [8]. Numerous spectators approached our work and expressed appreciation. Most of them took a long and close look at the animation, finally asking how it works. They wondered how the small 3D particles are able to fly or levitate inside the table. The most common reaction was: "Is it a hologram?" because the animated objects seemed translucent like a jellyfish. Yet, soon they realized that there were physical objects inside the table, and they began to marvel about the sophistication of the stars exploding in space. One spectator said, "I can see the life cycle of a star in a few seconds. Everything comes from the void and eventually goes back to it." "These small particles seem to be portraying the transmigrationism of Buddhism or Hinduism," said another spectator.

Fig. 2. *Sea of Stars*, Crystal Zoetrope, 400 x 400 x 710 mm, 2009. (©Woohun Lee and JinHa Seong. Photo © Whan Oh Sung.)



Conclusion

In this paper, we presented a miniaturized 3D Zoetrope produced with the SSLE technique. We applied the Crystal Zoetrope to the "Sea of Stars Table" in order to exemplify how this new visual medium can be embedded in various everyday objects or environments such as lighting, walls, floors, advertisements, or toys. The Crystal Zoetrope is a new visual medium that can make everyday objects more interactive and interesting. Perhaps, during your next visit to a pub or a museum, you might encounter an animated jellyfish swimming across your table.

The Crystal Zoetrope is different from traditional 3D Zoetropes, not only due to its small size and ease of production, but also because the SSLE technique allows even tiny animation particles to be engraved in a glass block, eliminating the requirement to connect them to any supporting structure. Consequently, the technique we proposed allows artists to portray subtle natural phenomena such as transforming nebulas in the universe or changing clouds in the sky with ease, as exhibited in the "Sea of Stars."

References and Notes

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