Magic Zoetrope: Representation of Animation by Multi-layer 3D Zoetrope with a Semitransparent Mirror

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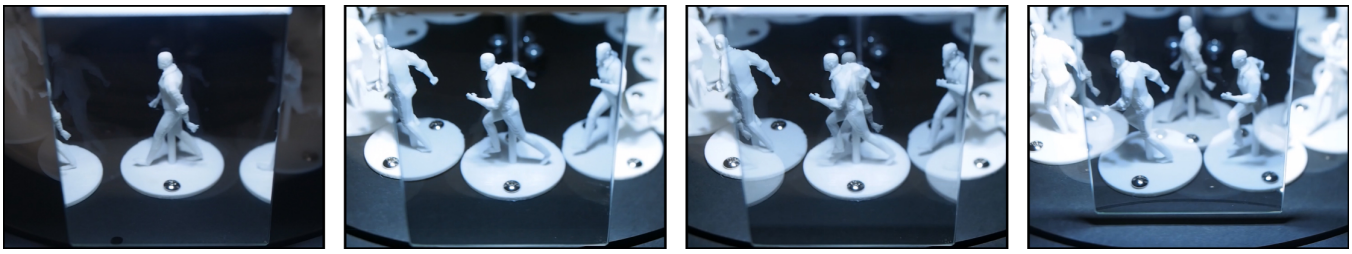

Figure 1: Multiple animations of the Magic Zoetrope that are represented without rearranging any objects: switching two animations from the walking man (left) to the running man (left middle), superimposing the two animations (right middle), and changing the positional relation of the two animations (right).

CCS CONCEPTS

• **Hardware → Displays and imagers**;

KEYWORDS

3D Zoetrope, display, multilayering, semitransparent mirror

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1 INTRODUCTION

In this research, we propose a multilayered 3D zoetrope called the "Magic Zoetrope", which makes it possible to animate two independent object groups concurrently and to represent various alterations in the animation, unlike a conventional 3D zoetrope. A conventional 3D zoetrope has only one object group that is illuminated by a unitary strobe light, so that the presented animation is always periodic and unchanged. Some studies [Miyashita et al. 2016; Smoot et al. 2010; Yoshida et al. 2016] and artworks, for example the Time Stratum series by Toshio Iwai, attempted to expand the range of expression of 3D zoetropes, but they did not focus on animating multiple subjects with alterations in the mutual relation between them as in the video animation.

The Magic Zoetrope is multilayered by two concentric 3D zoetropes and a semitransparent mirror. The mirror is arranged between the two zoetropes. We control these zoetropes individually and observe them by utilizing the semitransparent mirror, so that the two animations are presented concurrently regardless of the difference in fps and strobe emission timing of each zoetrope. Furthermore, the animations are presented with the various alterations as shown in Figure 1. For instance, we can present one or both of the two animations selectively at the superimposing position and change the positional relation between them while the turntable of the zoetrope is rotating continuously.

2 MAGIC ZOETROPE

2.1 System Configuration

The Magic Zoetrope consists of two concentric turntables, two strobe lights, two object groups, and a semitransparent mirror as shown in Figure 2. On each the inner and the outer turntable, there is an object group that has continuous movement or deformation in its shape for frame-by-frame animation. The semitransparent mirror is hung above the turntables and arranged vertically between the two object groups. The two strobe lights are arranged in front of and behind the mirror, respectively. Because the two turntables rotate individually, and each strobe light illuminates each object group in sync with its rotation, two zoetropes are constructed across the semitransparent mirror. By observing the two independent, concentric zoetropes through the mirror, the various new animations are realized.

2.2 Properties of Semitransparent Mirror

We use a semitransparent mirror to make the 3D zoetrope multilayered. A semitransparent mirror has both reflectance and transmittance, so it behaves as both an ordinary mirror and a transparent plate in the area with much relative difference in brightness between the front side and the back side of the mirror as shown in Figure 3. In such an area, because the reflected/transmitted light

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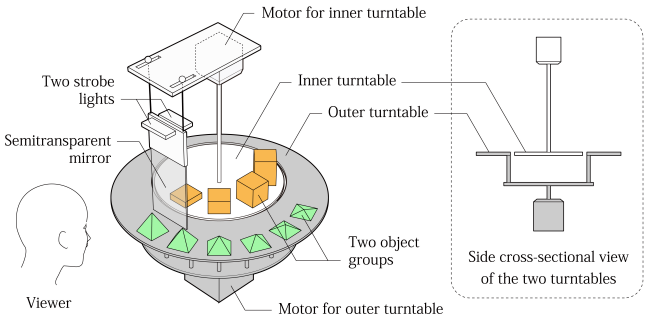

Figure 2: System configuration of the Magic Zoetrope.

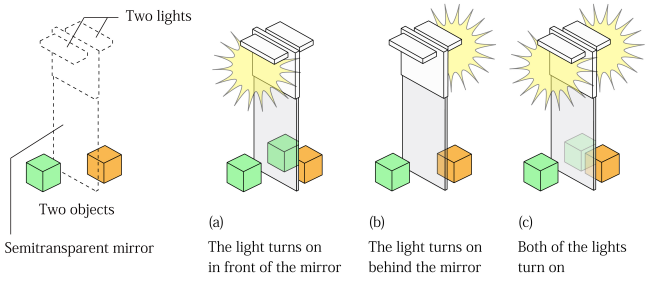

Figure 3: Changing the behavior of the semitransparent mirror.

from the darker side is canceled by the transmitted/reflected light from the brighter side, the mirror changes its own behavior.

2.3 Multilayering the 3D Zoetrope using the Semitransparent Mirror

We observe the semitransparent mirror arranged between the two concentric zoetropes from the front in a dark room. When the strobe light arranged in front of the mirror blinks, the mirror behaves as an ordinary mirror, and we can observe the animation of the outer zoetrope reflected in the mirror. When the other strobe light arranged behind the mirror blinks, the mirror behaves as a transparent plate, and we can observe the animation of the inner zoetrope beyond the mirror. In addition, when both of the strobe lights blink, we can observe both of the two independent animations concurrently in the mirror even if they have a different fps and strobe emission timing from each other. Two different turntables make the fps of the two animations independent quantity.

The outer zoetrope is observed as a virtual image in the semitransparent mirror, so that we can move the radial position of the virtual zoetrope by changing the distance between the mirror and the real figure of the outer zoetrope. When the mirror is arranged at equal distance from the inner and the outer zoetrope, the Magic Zoetrope presents the two animations at the superimposing position in the mirror. We can control which of the strobe lights blink and the radial position of the semitransparent mirror while the turntable is rotating; thereby, the Magic Zoetrope is multilayered, and various alterations are realized in the animation of the zoetrope.

3 DEMONSTRATION

3.1 Main Application

In the demonstration, participants can view various animations of human locomotion. Basically, the Magic Zoetrope presents animations of a walking man as shown in Figure 1 (left). While viewing the walking man, he starts running as shown in Figure 1 (left middle). In addition, the running man is presented next to the walking man and overtakes him as shown in Figure 1 (right). These animations are realized without rearranging any of the figures on the two turntables. The participants can arbitrarily select which animation is presented.

For these animations, we readied two different figure groups and circularly arranged them on each turntable at equal intervals. We arranged 24 figures in the shape of the walking man on the outer turntable and 12 figures in shape of the running man on the inner turntable. The outer turntable rotates at 1 Hz, and the inner turntable rotates at 2 Hz so that 24-fps animation is presented on each turntable. We set up the same fps in each animation for facilitating the shooting.

3.2 Potential Applications

This zoetrope has the potential for more expressions. One involves blending the colors of animations by superimposing two object groups that have different colors. Another involves representing animations with a change that takes a long time such as the deterioration of objects, visualized by gradually switching the before-state and after-state of the objects in the mirror. Another expression involves making the walking man on the outer turntable meander by shuttling the mirror to the radial direction and continuously moving the position of the virtual image in the mirror.

4 CONCLUSION AND FUTURE WORK

We propose the Magic Zoetrope, a multilayered 3D zoetrope that makes it possible to animate two independent object groups concurrently and to represent the various alterations in the animation. Because the current system uses only one semitransparent mirror, it can only be observed from one viewpoint. Furthermore, it has occlusion problem with the inner animation by the real outer figures when the system is viewed perpendicular to the axis of rotation. We will make it observable from multiple viewpoints by increasing the number of mirror and two strobe light pairs and circularly arranging them above the turntable.

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