Shadow Play: Creating Motion Art with Digitally Augmented Shadows

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ABSTRACT
Shadow casting possess different *physical affordances* that follow the laws of physics. Different shadow shapes and patterns can be created by manipulating the shadow's light source direction and intensity, the physical object's distance and angle, and the texture of the surface in which the shadow is casted. These physical properties can be used by the operator to create creative patterns with the projected shadows. Some of these *physical affordances* include playing with the shadow's movement, superposing different object's shadows and scaling the shadow's size by moving the physical object closer or further from the light source. As aesthetically pleasing with its unique black and white contrast, shadows are a fascinating form of media that can create different textures and details based on the skill of the user.

Shadow Play aims to enhance such a playful shadow experience to more advanced creative form of art by allowing users digitally manipulate their shadows. By adding new *digital affordances* Shadow Play, users can print and add layers of multiple shadows onto the screen, and invigorate them with animated effects and motions. With such various mix of augmented shadow effects, users can utilize their body as a tool for creating their own unique shadow artwork and animations.

Author Keywords
Tangible user interface, creativity support, new media, shadow casting.

ACM Classification Keywords
H5.2. Information interfaces and presentation (e.g., HCI): User Interfaces – Interaction Style.

INTRODUCTION
There exist multiple tools for creating artwork in human computer interaction. These tools span from simply scanning a physical artwork to handheld tools such as a computer mouse or an stylus. Human Computer Interaction researchers have suggested other methods for creating digital art pieces [1][2].

Shadow Play demonstrates another design tool / method for creating digital art utilizing shadow images projected from our body. Shadow Play augments shadow's *physical affordances* such as movement, shadow superposition and scaling (by bringing the projected object closer or further from the light source) by including a new set of *digital affordances* for manipulating the projected shadows. These *digital affordances* include loop recording, shadow mirroring, and effects with gesture recognition.

RELATED WORK
Shadow Play aims to introduce a design tool that uses shadows for artwork creation that builds upon works related to using shadows for figure creation.

Several researchers have suggested a way of using shadow for a design tool such as *Shadow Art* [3] to generate multiple shadow arts from a single object or *Shadow Reaching* [4] to use shadows as a physical metaphor and interaction tool.

There were also attempts to create digital figure using 3D objects or body shapes. *Surface Drawing* [5] presents tangible objects or hands as tools for 3D digital object / art creation for artists and designers. *Body Avatar* [6] is another example of translating body movement into a 3D digital figure (avatar) using the Microsoft Kinect.

SHADOW PLAY
Shadow Play allows users to create unique patterns and artwork using augmented shadows. New affordances include taking snapshots of the current shadow, which is then added onto previous layers, adding in animation and visual effects, such as shooting a fireball and mirroring shadows, and creating a loop of shadow motions. Users can also reset the screen to a blank canvas.

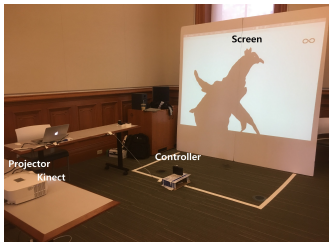

Figure 1. Setup of Shadow Play requires enough space to place projector, Kinect, and object activity area. Taped area on the floor is to guide users of the activity space

These new set of *digital affordances* are implemented with a projector a Microsoft Kinect and image processing software. The projector is used to display the captured digital shadows and as a light source itself. The Kinect's infrared depth sensor is used to detect the user's body contour and thus project an image the emulates the appearance of a shadow. The setup requires ample space

between the projector, the object area, and the screen. The object area needs to be at certain optimal distance so that the camera can recognize the object's motion. Because the users' body need to be within sight of the camera, taping the boundaries of each area helps users identify where they should stand. With the use of a projector, Shadow Play enables users to engage their entire body in the creation process, giving greater variability and control.

USER INTERACTION

CONTROLLER

Users use a camera-shaped artifact for selecting which *digital affordance* to use. Users can select different effects modes by turning the camera's potentiometer, and the current mode is indicated on the top right of the screen. Clicking the button on the camera puts the current mode into effect.

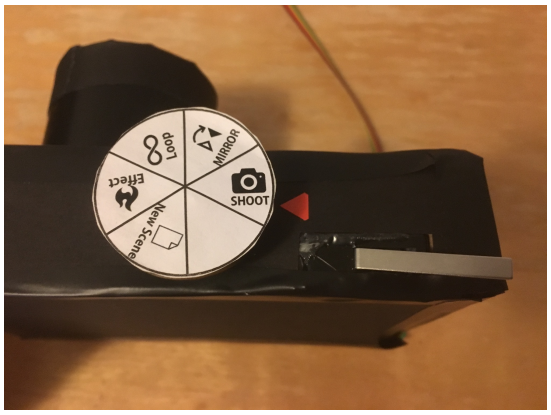

Figure 2. On top of the camera, potentiometer knob is located for users to switch between different modes of snapshot, mirror, loop, effect, and clear.

INTERACTIONS

Shadow Play introduces four main interaction tools for digital art creation; capturing, looping, mirroring, and special effects.

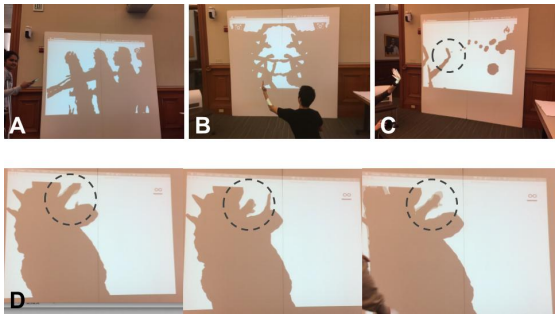

Figure 3. Capturing (A), Mirroring (B), Special effects shooting fire ball from a hand (C), and Looping (D) - dotted circle area highlights the animation created with the participant's hand movement

ART CREATION SCENARIO

To start the art creation process with Shadow Play, users first need to create their own shadow environment, which will be set as a background pattern. By using capturing feature, users can layer multiple shadows onto the screen.

The mirror effect also creates a symmetric figure which can be used to create novel patterns. Then, users can input dynamic motion into the scene using the loop feature, which records the shadow movements for 6 seconds. Once the motion is recorded, the shadow motion will automatically be added and be displayed as a constant loop.

Lastly, users can add additional animation effects. In effects mode, the user's arm is recognized automatically. Animated figure (GIF) is activated based on the arm's position which is used to activate effects, for example, shooting a fireball.

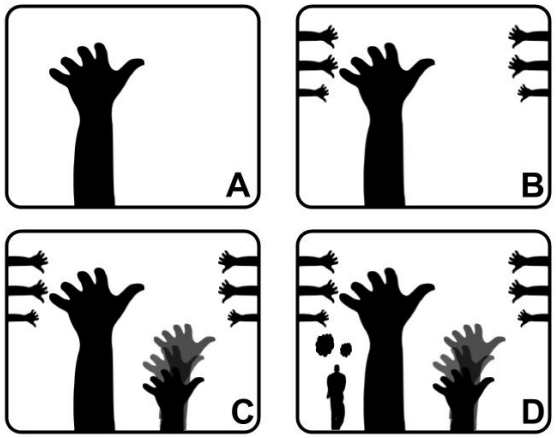

Figure 4. The user starts Shadow Play by capturing an image (A), adding more background layers using mirroring (B) and loop (C). Finally, user acts with an optional special effects such as fire ball from a hand.

With the mix of these features, users can create shadow artwork in playful environment. Shadow Play resembles the thought process and planning of an actual painting. Just as an artist would plan ahead where certain objects would be placed within the space before making the strokes, Shadow Play users have to deliberately organize the angle and distance of their body in order to perfect the layers of shadow into a single object shape. By having the augmented shadows displayed on the screen, there is a loop of feedback and manipulation as users constantly refer to the captured shadow to make adjustments accordingly.

USER TESTING

In order to validate the Shadow Play as an artwork creation tool, we let users to play with the system, create their own artwork, and give feedbacks to the tool.

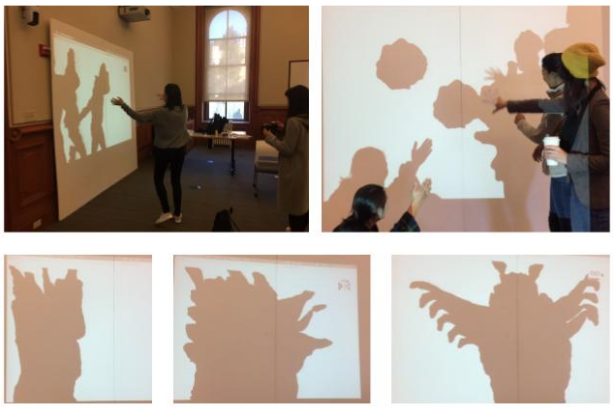

Figure 5. Works created by users using Shadow Play that shows two players working together, making contour using different features

Even though Shadow Play was originally intended for two players, with one user operating the camera artifact taking the role of a director and the other user(s) taking the role of performers, we had many single players trying to both act out and take snapshots on their own. As we had the object area and input device separated apart, users found it hard to take snapshots when they wanted to.

There were several actions from users that was found while using the system, such as placing a controller on the floor and pressing it with their foot in order to have full motion of the body. Also, having more than two players on the screen to play a game shooting special effects to each other.

LIMITATIONS AND FUTURE WORK

Some limitations from the user testing was that an offset created from the actual shadow and projected shadow blocked users to consider the projected black contour as a shadow. In order to improve the experience, the setup could be changed to have a more reliable calibration in a controlled environment.

One major consideration for future work is improving the interaction of input device. Because users found it easier to have them both act out and record, having a camera artifact was a cumbersome device to operate for the user rather than a physical metaphor of an art tool. Alternative solutions could be having a footstep as click button, or a wearable input device so that users can pose and easily click.

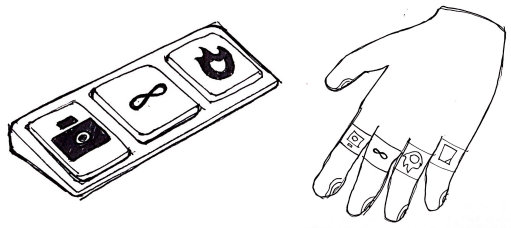

Figure 6. Examples of future iteration of more intuitive controller for Shadow Play

As for the prototype, we currently have only one effect of shooting the fireball. We can add in more dynamic effects, such as rays of light, snowing, and different patterns. However, with more addition of effects, we also need to take user interface into account as turning the potentiometer knob for all the various effects would be inefficient.

One potential solution is creating a physical palette with different effect icons. With the palette, a more direct metaphor of art creation is involved, and combining wearable input devices could create a more comfortable setting for users. Another option would let the user capture the projected shadow of an object, with an interesting shadow shape or patterns, and then use this captured image as part of the effect.

Shadow Play currently allows users to clear the entire screen instead of undoing single snapshots. Lacking an undo functionality limits the control of the creation process as users would have to reset the entire scene in order to undo their mistakes.

Another additional feature could is saving the displayed artwork to a seperate file. Most of the users wanted to capture their work after the interaction. What could be more interesting is recording the entire creation process that shows how users directly engage with the prototype because the interaction process provides playful scenes, and could become inspiration for other users' creations.

Moreover, new features could be implemented for storytelling such as allowing the user to record their own scenes and then rearrange in order to form their own stories. with the projected shadows.

Even with the limitations of the current Shadow Play setup, we could find various interesting digital arts created from the interaction with projected shadows by users. Further improvements of the research as mentioned will enable Shadow Play to become a new method of digital art creation.

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