
MagicWand: Exploring Physical Affordances with a Handheld Cylindrical Display Object

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Abstract

We introduce *MagicWand*, a cylindrical handheld display object made out of 2 Flexible Organic Light-Emitting Diode (FOLED) screens. Magic Wand features a smartphone running the Android operating system. Gesture recognition allows movements of the wand as a form of input. We were interested in exploring how a cylindrical form factor might offer physical affordances for action that are quite different from those of a traditional flat smartphone. We present an application scenario where MagicWand is used as a game controller that can display a variety of 3D game elements.

Author Keywords

Cylindrical Displays; Flexible Displays; Organic User Interfaces

ACM Classification Keywords

H.5.2. Information Interfaces and Presentation: User Interfaces – Graphical user interfaces (GUI)

Introduction

An *Affordance* is the intrinsic ability of an object to allow an action [5]. Affordances are typically generated by matching the fit of the body under action to the physical shape of the object. For example, a vertical



Figure 1: False affordances. As Magritte pointed out with "The Treachery of Images", an image of a pipe is not actually a pipe.

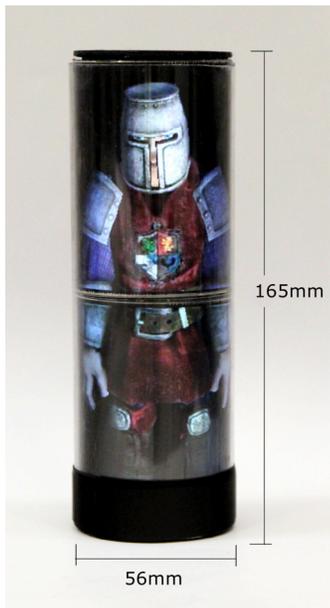


Figure 2: MagicWand. A handheld cylindrical display¹.

door handle affords pulling, whereas a horizontal flat bar affords pushing to open. In industrial design, the visual and haptic form of an object reveals its affordances, that is, the way in which it is used. While visual affordances are possible on a flat computer screen, physical affordances of shape are never met. This may create false affordances (Figure 1). As Gaver pointed out [3], false affordances may lead to errors, such as the inability of a user to determine the correct (gestural) action.

Organic User Interfaces (OUI) [4] use screens in non-flat shapes or forms. Therefore, OUIs allow physical affordances that traditional flat displays are incapable of providing: An OUI can supplement virtual objects with physical affordances provided by the shape of the display device. In this paper, we introduce MagicWand, a handheld display device with a cylindrical screen. MagicWand uses gesture recognition through its IMU as its primary input method. We discuss an application, a fantasy adventure game that takes advantage of MagicWand's features. In this game, MagicWand works as a game controller that displays different tools depending on the game context. Users discover gestures that operate the tools through visual and physical affordances.

Related Work

Handheld Volumetric Displays

In the past, the study of the effect of display shape on user experience and performance has been limited by the unavailability of display form factors other than flat. For instance, Poupyrev et al. [8] presented D20, an icosahedral display device rendered as a 3D object and controlled by an external non-display device. Pillias et al. [6] used a similar approach when exploring a hand-

held cylindrical form factor called Digital Roll. Akaoka et al.'s DisplayObjects [1] used projection mapping to render interfaces on the surface of objects, including the cylindrical DynaCan. Multi-faceted display prototypes have also been constructed by stitching flat displays together. Examples include Display Blocks [7] and pCubee [9], the latter adding a headtracker to simulate motion¹ parallax.

Wand Form Factor and Gestural Interaction

Wands have been traditionally used to support the expression of hand gestures in gaming environments. This has been explored in projects such as XWand [10], an electronic wand that allows a user to point at other devices for control. Similar form factors have been used commercially as game controllers, including the Nintendo Wii Remote, and Sony's PlayStation Move. This type of motion-sensing game controllers is sometimes credited with popularizing physical input in video games. Typical game controllers, however, do not feature embedded displays. One notable exception is the Wii U's GamePad. Although it has embedded inertial gesture sensors, it mostly relies on a joystick and buttons for input. While smartphones are an alternative for gestural input using built-in inertial sensors [2], they lack the wand-like form factor.

Implementation

Cylindrical Display

With two FOLED screens that cover almost all of its lateral surface, MagicWand can provide the visual illusion that displayed objects are enclosed within the device. Visual perspective correction is used to strengthen this illusion of a 3D display, and when the

¹ The soldier model is a free 3D asset from www.mixamo.com



Figure 3: A player interacting with MagicWand².

wand is rotated, the graphics are rotated according to IMU data to give the illusion of motion parallax. MagicWand has a radius of 28mm and a height of 165mm (Figure 2). Each screen covers half of the lateral surface of the cylinder, resulting a 160mm x 135 mm display with a narrow seam between screens, featuring a total resolution of 1440 by 1280 pixels. The displays are wirelessly synchronized to act as a single screen.

Gesture Detection

We designed MagicWand to rely primarily on gesture-based input. We developed a simple algorithm that tracks peak accelerometer values within a time frame in order to recognize input gestures, such as swirls, slashes, pointing or rotational actions.

Graphic Rendering

We developed a game application in Unity that runs on a server. The server communicates with MagicWand over a local Wi-Fi network. It receives and processes the incoming gestural data and sends the graphics to be displayed on the wand. In this system, MagicWand acts as a game controller. A large external screen is used as the primary game display. The server controls this display as well, running the game and coordinating all components.

Affordances and Gestural Interaction

Compared to a flat handheld display, a cylindrical form factor provides several affordances worth exploring in game play (Table 1). Flat displays have a discrete display area, limited to one side of the device. Typically, users grasp it with the fingers of one hand and interact with the fingers of the other hand via touch gestures. By contrast, a cylindrical display offers

| Form | Visibility | Grasp Affordance | Gestural Affordance |
|-------------|-------------------|-------------------------|----------------------------|
| Flat | Discrete | Fingers | Finger motion (touch) |
| Cylindrical | Continuous | Hand | Wrist motion (rotate) |

Table 1: Comparison of affordances offered by controllers with cylindrical and flat displays.

a continuous display area 360 degrees around the device. This allows users to grasp the device with one hand, making it ideal for wrist-based gestures (see Figure 3).

Game Application

To highlight some of MagicWand’s capabilities, we developed a first-person fantasy adventure game. The game requires the player to use several tools—a wand, a sword, a magic potion—to interact with characters in order to overcome obstacles or enemies. The final goal is to collect characters and transport them from the wand display to the large display.

During the game, tools and characters are rendered on the MagicWand, with the player having to discover the gesture to put the tool or character to action on the large display. We believe that the visual representation of the game objects, supplemented with MagicWand’s unique physical affordances, might make it easier for players to discover the new gestures. MagicWand currently supports the following gestures (Figure 4):

² The key model is a Free 3D asset from www.turbosquid.com

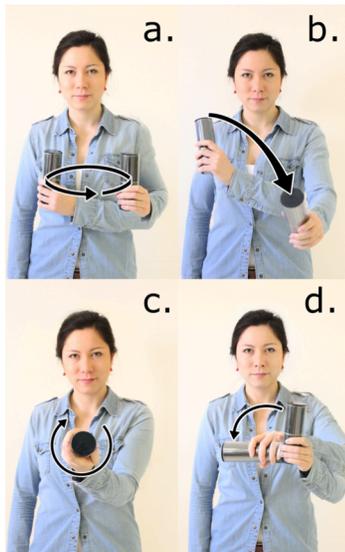


Figure 4: Gestures: a. Swirl, b. Slash, c. Rotation, d. Tilt

Swirl: A character floating inside an animated tornado is displayed on the wand. With a swirling gesture, the player accelerates the tornado and propels the character over obstacles to reach a goal.

Slash: When a sword is displayed on the wand, a slashing gesture allows the user to destroy a spider web that blocks the way. When displaying a virtual wand, a swirl followed by a slash is used to cast magic spells.

Rotation: A rotation gesture can be used when a key is displayed on the MagicWand, allowing the player to unlock a dungeon door.

Tilt: When the MagicWand displays a potion-like liquid, a tilt gesture allows the player to pour it into a cauldron to prepare a magic concoction.

Conclusions and Future Work

We presented MagicWand, a handheld cylindrical display device with gestural input, and an application as a game controller. We plan to conduct a study to compare MagicWand to a flat display controller (e.g., a smart phone) to evaluate its affordances for gestural interaction, as well as the effects of the cylindrical display on the players' user experience.

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