Cobra: Flexible Displays for Mobile Gaming Scenarios

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Abstract
We discuss Cobra, a handheld peripheral for computer games that applies flexible display design principles to provide a highly intuitive, mobile gaming experience. Cobra is a flexible plastic board interface that uses bends as input to the gaming device. The display is provided by a shoulder-mounted Pico projector. In this paper, we will present our prototype, the motives behind it, and its immediate applications.

Keywords
Organic User Interfaces, Mobile Gaming, Flexible Displays.

ACM Classification Keywords
H.5.2 [Information Interfaces and Presentation]: User Interfaces---input devices and strategies, haptic I/O

General Terms
Design, Human Factors

Introduction
In today's game hardware industry, the primary research focus has shifted from maximizing graphical power to creating new, more natural methods of interaction for players. Nintendo's Wii Remote, Sony's PlayStation Eye, and Microsoft's Project Natal are

examples of how new input devices is changing the way games are being played. However, these new solutions usually involve a stationary setup. As such, they are difficult to incorporate into handheld gaming consoles, and are typically designed specifically for home console scenarios.

With this work, we aim to bring the same kind of intuitive interaction seen in home consoles to handhelds by using organic user interfaces. An organic user interface is a user interface "with non-planar displays that actively or passively change shape via analog physical inputs" [1]. Such an interface would effectively provide the intuitive interaction we were looking for. We envisioned a flexible, handheld surface that players could twist and bend in order to provide input. Although interfaces exist that rely on deformation for input (e.g. PaperWindows [2], Gummi [3], and Foldable Input Devices [4]), these interfaces were not specifically designed for gaming, and have limitations that make them too slow or too unresponsive for gaming scenarios.

Hardware Implementation

The Cobra prototype consists of a flexible display board onto which a game is projected using a Pico projector. The game is run on a notebook computer worn in a carrying bag (Fig 1). Normally, to play games on a notebook computer, one must set the notebook down and remain seated in front of it. This is in stark contrast to handheld consoles, which allow users to play anywhere, anytime. On the other hand, notebook computers are much more powerful than handheld game consoles and are also more common. The decision to make Cobra a computer peripheral allows users to play games that leverage the power of notebooks, while at the same time giving them the level of freedom provided by handhelds. Thus, it makes computer gaming more mobile, and makes mobile gaming more powerful. As Figure 1 shows, a regular notebook carrying bag conveniently houses the entire Cobra system.

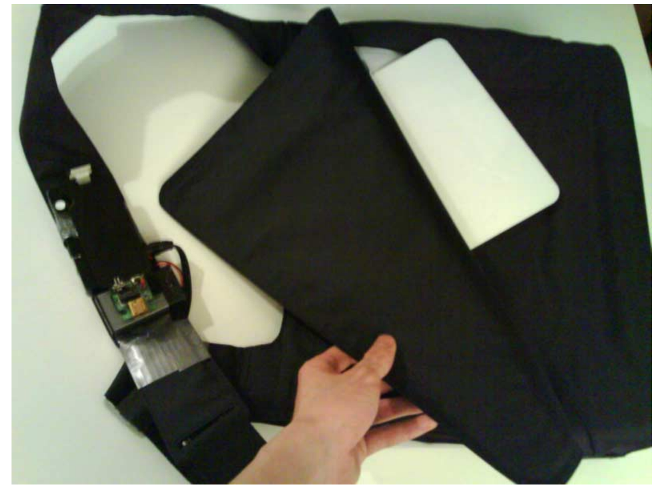

Figure 1. The prototype consists of a notebook carrying bag fitted with the projector, and an input/display board.

The central piece of hardware is the board (Fig 2). It serves as a display and an input device, and provides all communication between the player and the game. The exterior of the board consists of two sheets of thin, flexible plastic onto which an image is projected from a shoulder-mounted Pico projector. The board also exposes four infrared LEDs, which are tracked by a Wii Remote attached to the shoulder-mounted projector.

Sensing Deformation

The board's plastic is flexible enough to bend, but stiff enough to snap back into shape and not sag when held with one hand (Fig 2). Four bidirectional bend sensors and 2 pressure sensors attached to an Arduino Bluetooth [5] circuit board are used to sense the board's deformation (Fig 3). When in use, any bending or pressure sensed is communicated wirelessly to the computer. The current prototype detects bending of two corners and two sides, and has two pressure-sensitive points.

The other half of the hardware consists of a pocket projector and a disassembled Wii Remote, joined together, and attached to the bag's shoulder strap. These are adjusted to rest on top of the shoulder and point roughly towards where the board will be held. The projector cable runs under the bag's strap, and into the bag. The Wii Remote tracks the infrared LEDs on the board, and wirelessly communicates this data to the computer, which then uses this data to determine the board's position and orientation relative to the player. The screen area of the game being played is transformed based on this data, and the projector projects this transformed image onto the board. Like PaperWindows [2], Cobra uses a combination of computer vision and projection for tracking and display. This frees the board from having to have its own display, and allows it to be wireless. Unlike PaperWindows, however, Cobra does not use machine vision to detect bending. Instead, Cobra uses embedded sensors like Gummi [3], providing reliable and responsive input.

Figure 2. The front side of the Cobra board.

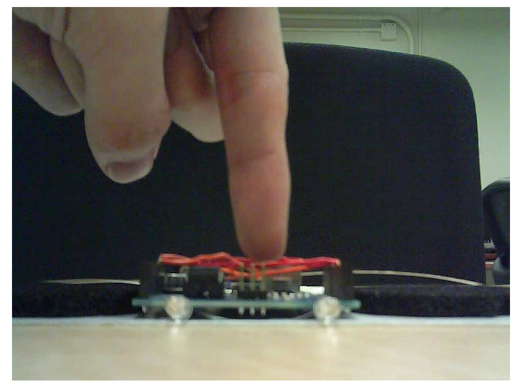

Figure 3. Side view showing board thickness and circuitry.

Software Implementation

We used a simple Arduino program to send the sensor data from the Arduino Bluetooth to the computer. Computer games interface with the Cobra through a custom library written in C#. The library reads the sensor data from the board, as well as the tracking data from the Wii Remote, processes the data, and provides the game with an abstracted representation of the board's current state. The game can then fire events and transform the screen image accordingly. These features can be turned on or off, so that the game can still be played in a traditional fashion without the Cobra. For testing, we wrote a few small 3D demos with OGRE [6].

Physical Interaction Styles

Digital inputs, such as buttons, restrict the human body's entire range of motions to just two possible states. Analog inputs, on the other hand, capture ranges of movement, and allow for more expressiveness. Because Cobra has many analog inputs, there are many possible gestures at the game developer's disposal. This gives rise to brand new, original game mechanics, designed to be intuitive to the player. Cobra does not come with a set of recognizable gestures, since the interpretation of sensor data is completely dependent on the game being played. It is up to the game developer to find the best control mappings. For example, grabbing hold of a corner of the board, bending it back, and releasing it can be used to shoot an arrow, cast a fishing line, or swing a golf club. The player is also able to gauge and adjust the power that goes into these actions, because the board's stiffness and other physical properties provide haptic feedback. An intuitive control mapping should create the closest match possible between the game world and the real world based on a physical metaphor. For example, an appropriate mapping for a driving game might require the user to bend the board left and right in order to steer the vehicle, while using the pressure points as the gas and brake pedals. A first-person shooter might take advantage of the spatial relationship between the board and the player for navigational controls. By combining the high degree of freedom and passive haptic feedback provided by the board with appropriate control mappings, developers can create physically engaging games.

Usability

Since most notebook users carry their computers around in a bag anyway, the only extra load Cobra requires is the board and the shoulder-mounted projection unit. When not in use, the board fits nicely in the bag with the computer. While playing, the user is free to move around in the real world. The tracker only acquires the board's position and orientation relative to the user, so the user's actual position and orientation in the real world do not affect the game.

Figure 4. A Cobra player in action.

Figure 5. Sample game projected on Cobra board.

Because the projected image is transformed to follow and fit the board, objects and people in the user's vicinity are not affected by the projection. This makes Cobra private and non-invasive, unlike other projection-based interfaces, such as Wear Ur World / Sixth Sense [7]. When the user lowers the board or moves it out of the way, it leaves the projector's light cone, and the entire projected image disappears, thus saving battery power. When the player wants to stop playing, he or she simply puts the board back into the bag.

Conclusion

Organic user interfaces allow for a much higher degree of expression than traditional, rigid interfaces. This makes them ideal in the context of gaming, in which there is a great need for player expression and intuitive interaction. Since organic user interfaces are also displays, they serve well as handheld devices. An intuitive, mobile gaming platform will change not only the way that mobile games are played, but also the way they are made. While the focus here is on gaming, a peripheral like Cobra could just as easily be used to watch movies, manipulate 3D objects, or mix audio. There are numerous domains which would benefit from a flexible, mobile display interface.

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