Brainy Hand: An Ear-worn Hand Gesture Interaction Device

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Abstract
Existing wearable hand gesture interaction devices are very bulky and cannot be worn in everyday life, because of the presence of a large visual feedback device. In particular, an eyeglass-type head-mounted display is very large for constant usage. To solve this problem, we propose Brainy Hand, which is a simple wearable device that adopts laser line, or more specifically, a mini-projector as a visual feedback device. Brainy Hand consists of a color camera, an earphone, and a laser line or mini-projector. This device uses a camera to detect 3D hand gestures. The earphone is used for receiving audio feedback. In this study, we introduce several user interfaces using Brainy Hand. (e.g., music player, phone)

Keywords
interaction device, input device, wearable, hand gesture, laser, audio feedback, projector

ACM Classification Keywords
H5. Information interfaces and presentation (e.g., HCI):
H5.2 User Interfaces – Input devices and strategies (e.g., mouse, touchscreen)

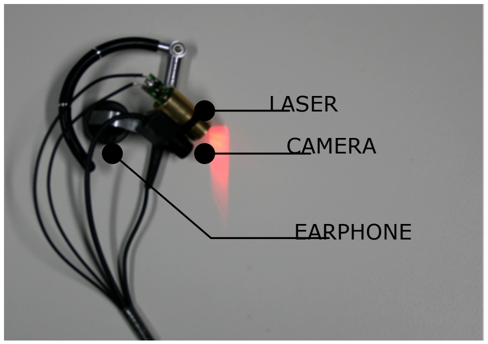


Figure 1. Simplified brainy hand.

Introduction

Wearable hand gesture interaction devices are believed to be effective user interfaces, because many people communicate using hand gestures. Moreover, hand gesture input system doesn't require plane desk. Therefore, a number of such devices have been proposed.

HandVu[1] is a device that consists of a camera and a head-mounted display. The camera and an electronic substrate are placed on the head-mounted display. This device is connected to a computer placed in a backpack. Even though the device is used as a hand gesture interaction device, it is difficult to wear it all the time, because of its weight.

Tinmith[2] is a lightweight hand gesture interaction device, which is designed with a helmet comprising a head-mounted display. The device detects hand gestures by recognizing 2D makers on the hand gloves using a camera. Users can monitor their own gesture inputs and feedbacks in mixed realty world through the head-mounted display. *Tinmith* is an excellent device in that it provides a lot of information to the user. However, it is difficult for the user to always wear the helmet with the head-mounted display. In other words, it is impractical for the user to wear this device while eating, talking, and sleeping.

Weavy[3] is a compact and lightweight hand gesture interaction device. This device is compact and lightweight because it comprises a one-eyed head-mounted display. However, this device is inconspicuous in that it occasionally obstructs the view of the user.

Although wearable hand gesture interaction devices have to be not only lightweight but also compact and inconspicuous, existing wearable hand gesture interaction devices are very bulky and cannot be worn in everyday life, because of the presence of visual feedback devices such as a head-mounted display.

To solve the abovementioned problem, we propose Brainy Hand, which is a simple device that avoids the use of displays. Functions of the display are to inform the user about the range of camera, provide operation feedbacks, and present the drawn words and images. In the case of Brainy Hand, a projected laser line is used to inform the user about the range of the camera. An earphone is used for receiving operation feedbacks. When the system provides considerable amount of information, a mini-projector is used to draw words and images on the user's hands.

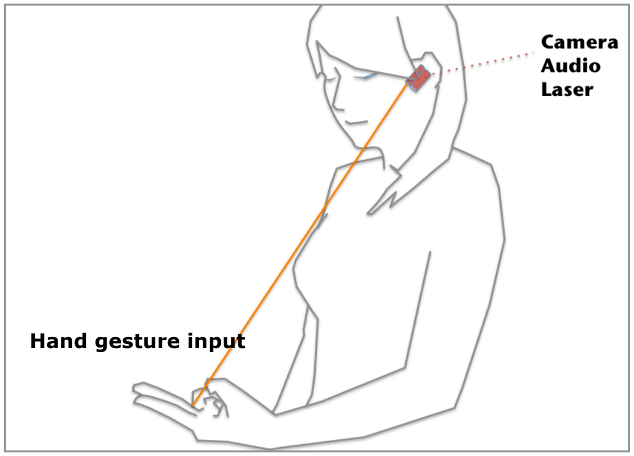
The proposed device consists of a camera, an earphone and a laser line, or more specifically, a mini-projector used for providing visual feedback. This device is very compact and lightweight, and easily set with ducking out of view on earphone, which is a popular wearable device. In other words, Brainy Hand without any display can be used as wearable hand gesture interaction devices that can be worn in everyday life.

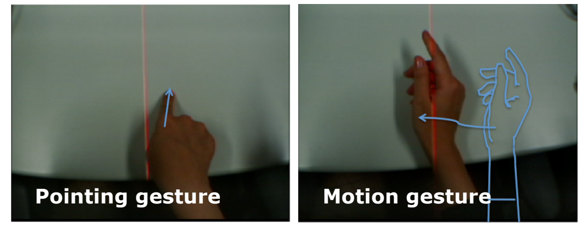
In this study, we introduce two versions of Brainy Hand, namely, the simple and projector versions (Fig. 2). The simple version of Brainy Hand uses a laser line. The projector version uses a mini-projector. We develop the simple version of Brainy Hand in practice. In addition, we develop a music player application using Brainy Hand.

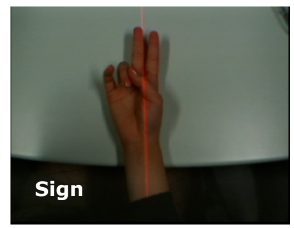
Brainy Hand Configuration 1: Simple Version

In this section, we introduce the simple version of Brainy Hand that uses a laser line (Fig. 1). In this version, Brainy Hand consists of a single color camera for 3D hand gesture recognition, a laser line as a visual maker to inform the user about the visible range of the camera, and an earphone for receiving audio feedbacks. And this device connected by a wire to a PC or PDA.

Simple Version





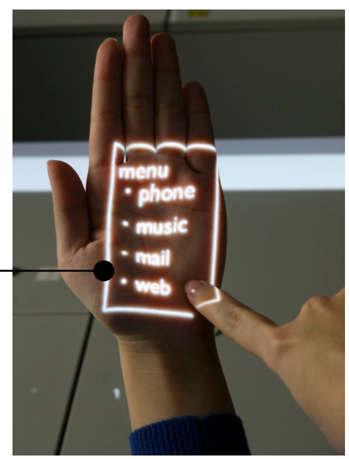


Camera is used to detect hand gesture. Line laser is used for providing visual feedback, and it acts as a visual maker. This device is used to perform one-handed operation

Projector Version

This version device uses a small projector to receive visual feedback.

User performs a two-handed operation.



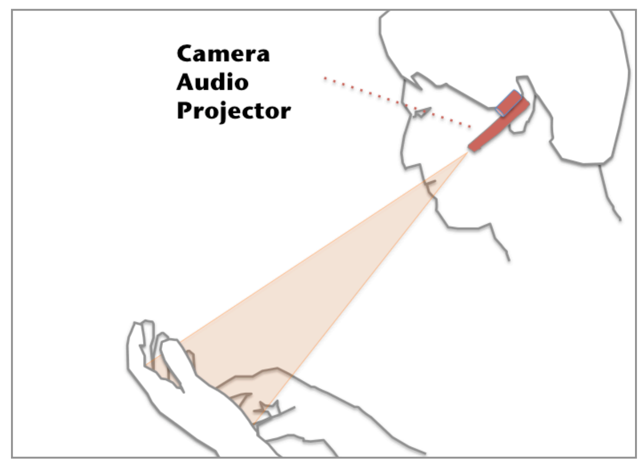


Figure 2. Two versions of *Brainy hand*.

Figure 4. Hand gesture input by using *brainy hands*.

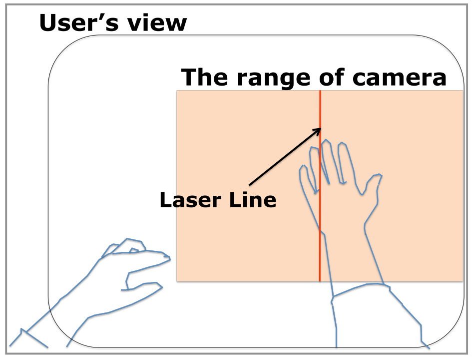


Figure 3. A Laser Line indicates the range of the camera.

Users operate by attaching Brainy Hand to one ear. They can observe the width of the range of the camera using a guided laser line (Fig. 3). The device detects hand gestures, as long as the user's hand is around the laser line. The system recognizes hand signs by matching the captured hand's contour with those contours and signs stored in the database. When more than five signs are to be detected, the system uses a 3D hand gesture estimation technique, which is described in a later section.

We developed the simple version of Brainy Hand in practice. Figure 4 shows that in reality, this configuration is small and inconspicuous.

Configuration 2: Projector Version

In this section, the projector version of Brainy Hand is described. In this version, Brainy Hand uses a small projector for projecting images and words on the user's palm. The projector is useful when the user needs to be presented with a large amount of information that must be read out. Users can easily perform an input operation using both hands. The bottom-left picture shown in Figure 2 shows an example of the projected information on the user's palm.

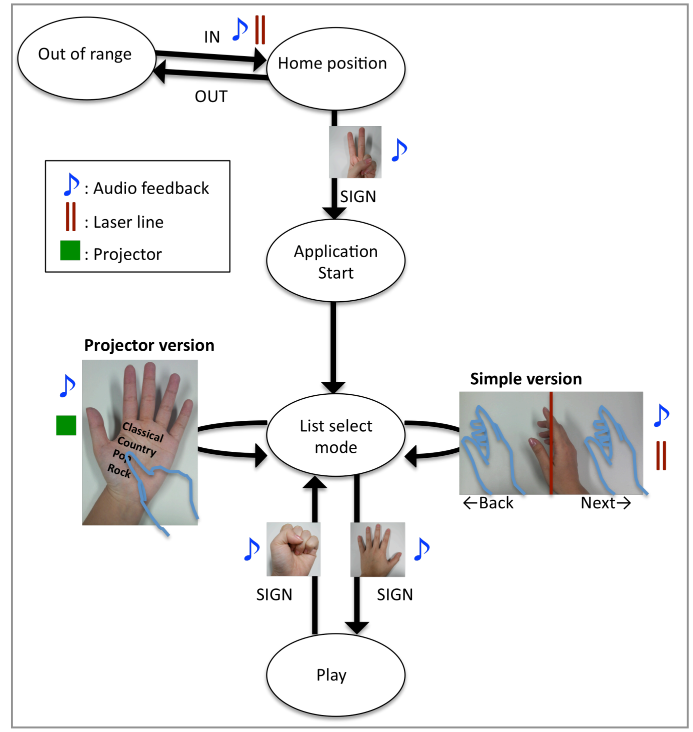


Figure 5. State transition diagram of music player.

Application Example: Music Player

We developed a music player as an example of the application of Brainy Hand. Figure 5 shows a state transition diagram. With a few signs, users can operate simple applications such as this music player.
In a select mode of music lists, the laser line indicates the visual maker as well as the range of the camera. On the side of laser line, users can control the selected music. The title of the selected song is spoken as an audio feedback, when it is too long to read out. The projector version of Brainy Hand is very useful.

Technical Back ground: 3D Hand Gesture Estimation

For estimating a 3D hand gesture, our system uses a single camera without creating any makers on the user's hands.

The system searches a similar data sets from the database to estimate the 3D hand gesture. The database consists of data sets of a hand contours, nail positions, and finger joint angles (Fig. 6).

Our system creates data sets while a color camera captures gestures involving a moving hand wearing a data glove, a white glove, and with artificial fingernails. We use an 18-DOF sensor Cyberglove from Immersion as the data glove. The white glove is used to eliminate the textures of the data glove.

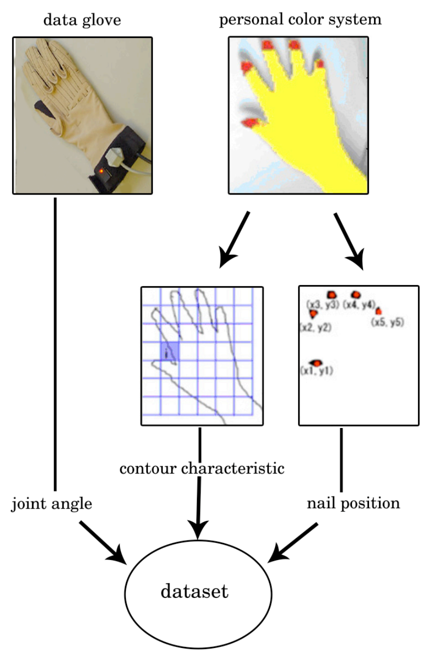


Figure 6. Construction of dataset in database.

Hand contour is digitalized using a higher-order local auto-correlational function(HLAC)[4]. Nail position is defined with respect to the center of the area of the nail.

When the system estimates 3D hand gestures, the nail areas and skin areas are extracted by projecting the RGB pixels of the captured image on to the user's personalized color space[5] (Fig. 7). Then, the system searches a similar data set with nail positions and the hand contour data from the database. Finally, the system outputs the finger joint angles of the data set as a result of the search (Fig. 8). The similarity is defined by weight sum of Euclid distances of nail positions and contour features.

We test by comparative experiments between the data glove and our system. Our experimental results show high accuracy in estimating hand gestures with the wrist rotation, such a standard deviation of error of approximately 7.23° in estimation of the finger joint angles (Fig. 9).

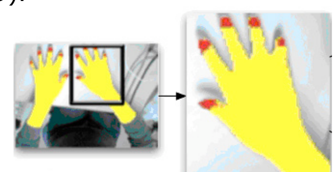


Figure 7. Extractions of nail and skin areas.

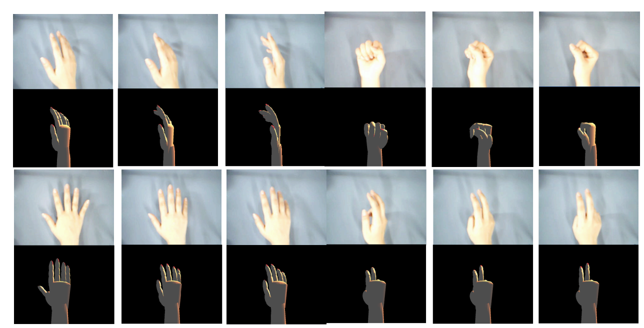


Figure 8. Results of 3D hand gesture estimation.

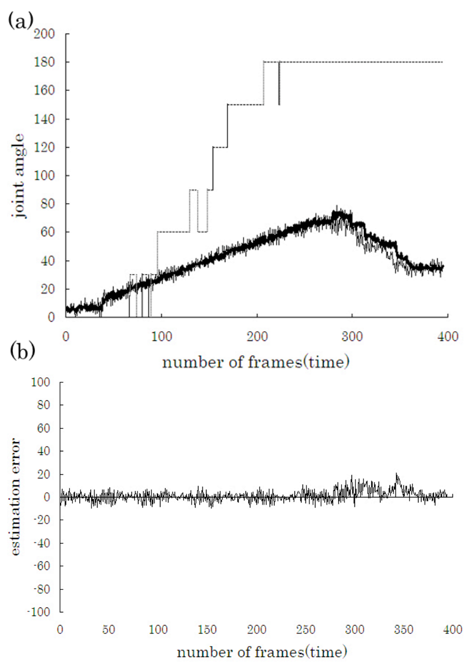


Figure 9. Estimation of middle finger joint angle with the wrist rotation. (a)Thin line represents the result obtained from our system. Heavy line represents the measured joint angle obtained using data glove. Dotted line represents the wrist rotation angle. (b)Thin line represents the estimation error.

Conclusions

We propose a small device; *Brainy Hand* which avoids the use of a display. We describe two versions of this device, namely, simple and projector versions. In the simple version, *Brainy Hand* consists of a color camera, an earphone, and a laser line.

In the projector version of *Brainy Hand* consists of a mini-projector, which is used as a visual feedback device. The camera is used to estimate 3D hand gestures. The laser line is used to inform users about the range of camera. The earphone is used for receiving operation feedbacks. When the system provides large amount of information to be read out, a mini-projector draws words and projects images on the user's hands.

We developed the simple version of Brainy Hand in practice, and confirmed that in reality, this device is compact, lightweight and inconspicuous of view. In addition, a music player is developed as an application example by using *Brainy Hand*.

Acknowledgments

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