Free Hand Interface for Controlling Applications Based on Wii Remote IR Sensor

Jiaqing LIN* Hiroaki NISHINO† Tsuneo KAGAWA‡ Kouichi UTSUMIYA§
Department of Computer Science and Intelligent Systems, Oita University

Abstract

Wii remote, a remote controller device attached to Nintendo game console, provides an inexpensive and compact hardware solution with an embedded infrared camera and accelerometers useful for tracking objects in a 3D space. We present an approach for building a unified gesture-based interface with the Wii remote device. We adopt it for tracking a user's hand motions and using the tracked motions to control applications. For example, the user can easily browse pictures, read e-books, and make presentations via the unified free hand interaction (FHI) method based on the Wii remote device. When the user utilizes his/her hand for making a simple gesture in the proposed system, the gesture will be registered by the system for controlling applications. He/she can simultaneously hold another Wii remote by the other hand for making auxiliary operations, or he/she can edit some specific functions of the registered gestures such as zooming in and out, changing page, and confirming operations.

Keywords: free hand interface; gesture interaction; object tracking; sensor input;

1. Introduction

Today, computers and computer-generated images are occupied and used in many aspects of our daily life. Computer imagery especially is found in many media and activities such as presentation materials, newspapers, weather reports, and surgical procedures. The image visualization technology significantly improves the quality and intuitiveness of output information, but input part still depends on some traditional ways such as keyboard typing and mouse pointing.

*e-mail: v09e3028@oita-u.ac.jp
† e-mail: hn@oita-u.ac.jp
‡ e-mail: t-kagawa@oita-u.ac.jp
§ e-mail: utsumiya@oita-u.ac.jp

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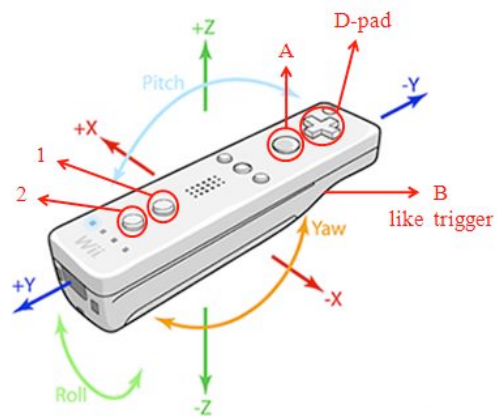


Figure 1: Wii remote configuration with its detectable 6DOF (degree of freedom) input information. (The figure of Wii remote is used from http://nkeegamedev.blogspot.com)

Recent advancements in input technology in game and mobile fields provide the potential power for inventing more intuitive and easier-to-use human computer interaction (HCI) methods. The Wii remote (nicknamed "Wiimote") device as shown in Figure 1 is such an example off-the-shelf device. It is one of the most popular and sophisticated interaction devices in the world now. It was announced by Nintendo in September 2005 as an interface for the Wii games console. It provides multiple inputs (an infrared camera and accelerometers) and output (a speaker, LEDs, and a vibration motor) functions combined with the ease of PC connectivity. The Wii remote's rich I/O functions made it a popular platform for exploring alternative control schemes for controlling applications. Many initial projects in the HCI community tried to use expensive and complex-to-use motion sensors for controlling applications and synthesizing operations [1]. The Wiimote contains an infrared camera with a built-in hardware component tracking up to 4 blob objects. This function significantly outperforms any PC "webcam" available today [2] and can be used as an inexpensive and easy-to-use alternative over the traditional motion tracking solutions. It can identify the position of an object moving in a 3D space at 100Hz. It is not only working in daytime, but also working at night without other light source. It also contains an accelerometer stimulating new ways of interaction methods and an expansion port for adding more devices and capabilities.

This paper proposes a unified way for interacting with the computers and applications. The proposed system allows users to track their fingers in 3D space by using the Wii remote's built-in infrared camera with an LED array and reflectors. This interface enables them to simply interact with computers and applications by waving and sweeping their hands in the air [7].

2. System Components

2.1 Wii remote

Since the release of the Wii game console, the Wii remote was attached to the console and many users have been exploring new and different ways for using it. Some programs were developed for allowing the users to use the Wii remote in a personal computer operations by emulating a keyboard, a mouse, and a joystick. The Wii remote can be connected to a personal computer via a Bluetooth communication channel. When the users press both of the "1" and "2" buttons placed on the device simultaneously or press the red "Sync" button in the battery case, the Wii remote's LEDs start blinking, indicating it's in a discovery mode. The users need to make sure their computer has a Bluetooth adapter and proper drivers [5]. Up to four devices can be used with a single Wii console at the same time. A main feature of the Wii remote is its motion tracking capability, which allows the users to interact with and manipulate items on a screen via gesture recognition and pointing through the use of accelerometer and optical sensor technology [1]. The Wii remote has the ability to sense acceleration along three axes (x, y, and z) [3] and the effects of gravity can be used to determine relative rotations as shown in Figure 1. The Wii remote also provides a sound output (speaker) and a tactile feedback with vibration motor.

The proposed FHI system allows the users to assign specific functions for the buttons placed on the device for easy customization. Example assignments of the buttons are as follows:

- Set the "D-pad" button to select functions used in the FHI system. The "D-pad" is accessed by slightly extending the thumb and its appearance maps to "go forward and backward", or "turn left and right" motions in the plane of the controller.
- Set the "A" button to confirm the selection done by the "D-pad" button above.
- Set the "B" button placed underneath the controller to deactivate the selected functions in the FHI system. The button can be operated by the index finger

The infrared camera manufactured by PixArt Imaging is built inside the Wii remote. A chip fabricated with the camera features an integrated multi-object tracking engine. It provides a high-resolution, high-speed tracking of up to four IR light sources. The camera sensor notifies the location data of the tracked objects with a resolution of 1024 * 768 pixels, more than 4 bits of dot size or light intensity, a 100 Hz refresh rate, and a 45 degree horizontal field of view [1].

2.2 LED panel

Because the Wii remote camera is sensitive only to the bright sources of infrared light (IR), we made a panel consisting of an array of hundred LEDs emitting IR on the tracked objects as shown in Figure 2. Figure 3 illustrates how the Wii remote and the LED panel are configured in the system. Both components should be placed in front of the user and the Wii remote should be put on the back of the LED panel. The user can see the infrared camera through the hole in the center of the LED panel. Infrared rays emitted from the panel shine on the user's hand and some of the rays are reflected by the user's fingers as shown in Figure 3. The reflected rays are received by the Wii remote's infrared camera and the position of the fingers are detected and returned to the application systems via Managed Library for Nintendo's Wiimote [6].

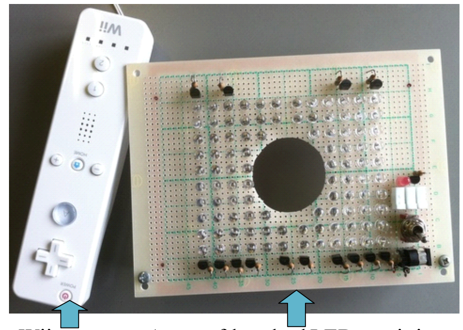


Figure 2: LED panel used for object tracking with built-in infrared camera inside Wii remote.

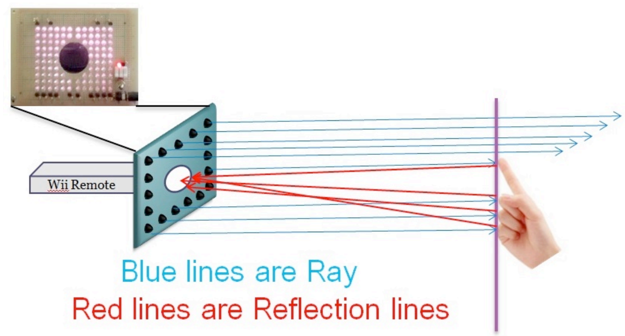


Figure 3: Configuration of LED panel with Wii Remote.

3. System Implementation

The main purpose of this research is to improve the way for human-computer interaction (HCI) by using a commodity interface device such as the Wii remote. The proposed HCI method enables the user to simply and pleasantly interact with computers and applications just like the video game interactions. He/she can control various application systems such as viewing pictures, reading e-books, and making presentations via the unified FHI system. In this section, we describe the architecture and GUI implementation of the system, and some example applications controlled by using the proposed system.

3.1 System architecture

Figure 4 shows the architecture of the proposed system. It assumes to use a pair of Wii remote devices for interacting with various applications. A tree structure in the figure illustrates the organization of software components in the system. The green part manages the first Wii remote used as a motion tracker in the system. The red part manages the second Wii remote used as an auxiliary input and output (feedback) device.

The first Wii remote enables the users to simply interact with applications by using one-handed motions such as waving and sweeping in the air similar to the interaction method seen in the American movie "Minority Report" [2]. The modules governing the motion tracking are "IR Aiming" and "Audio," the green boxes in the tree in Figure 4. The IR Aiming module is to register multiple gestures when he/she plays them with one-handed motions such as shaking a finger from side to side [6] [7]. If the Wii remote can accurately identify the gestures, the device attached to the LED panel responds the user with a beep sound from its built-in speaker

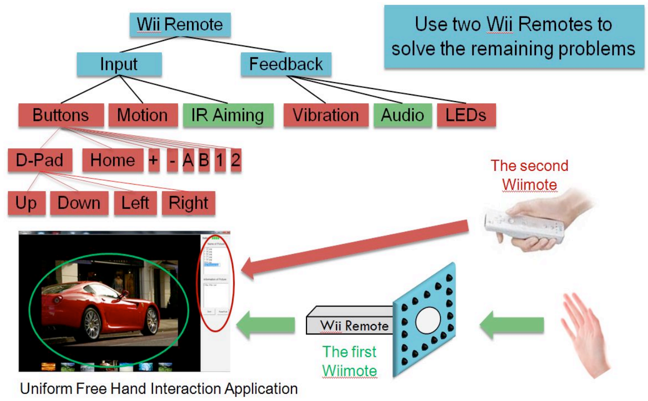
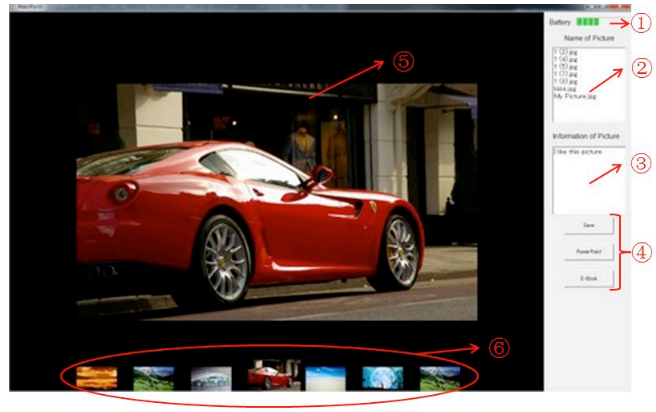


Figure 4: Unified free hand interaction (FHI) architecture based on Wii remote technology.



1: Battery display
2: Name list
3: Supplemental information
4: Function buttons
5: Work area
6: Thumbnail list

Figure 5: Screen snapshot of prototype application.

as shown in the bottom of Figure 4. The sound gives him/her a feedback about whether the presented gesture is correctly identified or not. FHI systems provide the process for sampling user's gesture and registering it. And then, FHI system can identify the registered gesture when the user presenting it with the same motion.

The red modules in the tree shown in Figure 4 manage the second Wii remote used as an auxiliary input and output (feedback) device. The user holds this Wii remote by another hand just as he/she playing a common Wii game using the controller. The red modules for the secondary device include "buttons", "motion", "vibration", and "LEDs" [11]. The function of "A" button in the "buttons" module provides the same function with the left mouse button for confirming operations. The function of "B" button is used to close the currently running application. A pair of "+" and "-" buttons enables the user to execute increment and decrement operations such as forward and backward a picture, a page, or a slide in the applications. The user can also switch pictures, pages, or slides via the above mentioned gesture function. The functions of "D-pad" button, as the name suggests, can be used for selecting an item in a list box (a red circle shown in Figure 4). In addition to the sound feedback as mentioned above, the secondary device reminds the user with vibration (tactile feedback) when he/she correctly finishes an operation. If any error occurs, the device's LEDs will blink as a caution signal.

3.2 System GUI and its prototype application

A feature of multi-modal interactions including images, sounds, and haptic feedbacks significantly improves the way for HCI [4]. Among many types and models, the Wii remote supports a very cost effective solution for implementing the multi-modal interaction environment and is proven to be a useful infrastructure for creating intuitive HCI methods.

In this section, we exemplify our approach through the design and development of system GUI for managing operations and a prototype application developed for verifying the effectiveness of the proposed method. Figure 5 shows the screen snapshot of the application. It provides three different functions, an image viewer, an e-book reader, and a presentation slide show. After successfully connect the Wii remote with the host computer via Bluetooth communication channel, the FHI system as shown in Figure 4 is activated. Then, the user can start and use the application anytime. Functions of the GUI components labeled as one through six in Figure 5 are as follows:

(1) *Battery display* shows the remaining electricity of the connected Wii remote.
(2) *Name list* shows a list of objects (images, books, or slides) for browsing. The user can assign an easily understandable name for each object in this list. Changing the name, however, needs a mouse for clicking a specified image and a keyboard for typing the name in the current implementation.
(3) *Supplemental information* describes additional data on referred objects. The information needs to be typed by using a keyboard in the current implementation.
(4) *Function buttons* consists of three buttons for selecting a desired function among the image viewer, e-book reader, and presentation slide show. The e-book reader button brings a module for showing an e-book file in PDF format, and the slide show button calls the Microsoft PowerPoint file and executes the slide show function. The user can operate with their natural hand motions in each function as described later in this section.
(5) *Work area* is a main field for interacting with the application. The user can switch objects (images, book pages, and slides) displayed in this field through their hand motions.
(6) *Thumbnail list* shows a list of accessible objects in thumbnails under the current functional mode. In the case of the image viewer as shown in Figure 5, it displays up to seven images among all pictures in the selected file. The currently displayed picture is displayed in the center and the neighboring six images are showed on both sides.

Under the operational environment with GUIs mentioned above, the user can perform various operations by using their hand motions in the three application functions as follows:

(A) *Image viewer*: The user can browse images by moving their hands or only shaking their finger from side to side for switching images back and forth. He/she can also rotate and zoom in and out a browsing image by rolling two fingers and changing the distance of them in front of a display screen. The sequence of displayed images can also be immediately changed through the name list interface mentioned above.

(B) *Slide show*: In the slide show function, the user can control the standard built-in slide show functions supported in Microsoft PowerPoint and OpenOffice through their hand motions. Firstly the user specifies and load a set of

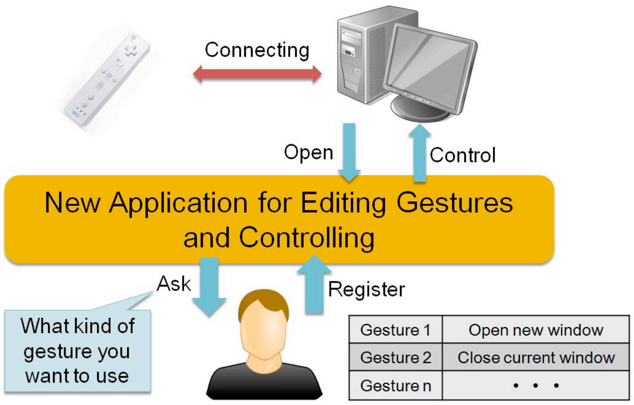


Figure 6: Enhanced free hand interface for supporting multiple applications.

PowerPoint documents in the system. Then, he/she selects a specific file in the name list GUI for making presentation. In the slide show mode, the user can switch the slides by shaking their finger from side to side. This switching action need to keep slow speed for reliable movements. He/she cannot only turn over the slides by moving forward and backward, but also use their fingers for writing signs and sentences on the slides.

(C) *E-book reader*: In the e-book reader function, the user can change the page of a reading book by swinging their one finger upward or downward. It is the same operation with the slide show function.

Whereas some functions in the current implementation needs mouse and keyboard operations, we successfully implemented basic operations as controllable ones by simple hand motions. In a preliminary evaluation, we found the proposed motion-based interaction method effectively improves the intuitiveness and accuracy of operations.

4. Further Improvements

Identifying varied gestures and easily integrating existing applications in the proposed interaction method is an important part of the research based on the Wii remote technology [8] [10]. As shown in Figure 6, a functional framework for integrating the user-defined application into the motion-based operational environment is required. Under the framework, the user interacting with a specific application receives a request for confirming and registering some gestures used in controlling the application. The system can efficiently increase the gesture vocabulary for controlling the existing applications. Implementing the framework is our future enhancement.

5. Conclusion

This paper presented a design approach and an implemented prototype application for realizing an intuitive HCI method using a commodity interaction device, the Wii remote. The proposed system enables a user to simply and pleasantly interact with computers and applications just like video game interactions. While the system still is an initial version and it requires the use of keyboard and mouse in some operations, it successfully implemented basic functions (switching, zooming, rotating etc.) to be controllable ones only by using simple hand motions.

We should conduct an experiment for quantitatively evaluating the effectiveness of the proposed method and the application. We also would like to continuously improve the operational environment as a truly natural interaction environment in the future. Providing a way for using the gesture-based interactions to manage operations in an AR (Augmented Reality) environment is a promising approach.

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