
U-Remo: Projection-assisted Gesture Control for Home Electronics

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Abstract

Various home appliances and electronic devices require remote control in homes, such as air conditioners and televisions, and the number of household remote control devices is increasing. However, the users of remote control devices sometimes experience stress because they might forget where they left a device, or they might have problems selecting the correct control from an array of confusing devices. Thus, we propose an innovative control method for home electronics that detects user gestures, where the prompts for gestures are projected onto the user's body. We also designed gestures and a GUI, which are highly intuitive and easy to understand. We refer to this system as "U-Remo" (ubiquitous + you are the remote control). As an example of this method, we applied the U-Remo system to an air conditioner. We developed a prototype system that comprised an air conditioner embedded device, a depth sensor camera, and a projector, which allowed the detection of user actions and the provision of graphical feedback based on the user's actions.

Author Keywords

Air conditioner; Gesture; Home appliance; Projection; Remote control

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

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Introduction

Most current home appliances and electronic products such as air conditioners or televisions are operated by a remote control device. However, the users of remote control devices sometimes experience stress. For example, it is easy to forget where a remote control was left and it might be difficult to identify the correct remote control among an array of confusing remote controls. Understanding the correct buttons to press on a remote control can also be non-intuitive.

A possible solution to these problems is the device-free operation of home appliances without the need for remote controls. It is also important to design intuitive and readily understandable systems. In this study, we propose an innovative remote control system, which we call "U-Remo," i.e., ubiquitous + you are the remote control (Figure 1). This system detects user actions and projects usage instructions onto the user's body, which prompt the correct gestures required to operate home appliances. As an example of the use of this system, we applied U-Remo to an air conditioner.

Related Work

Many studies have proposed various prototypes and products for operating home electronic devices in a device-free and intuitive manner. We categorize previous research into four types: (1) gaze operation; (2) voice and sound operation, such as claps; (3) gesture operation; and (4) operation via a projection system.

For example, Jurek [1] proposed a system that recognized the user's point of gaze based on an eyeglass-type device with an embedded infrared camera, which operated a cursor on the menu screen of



Figure 1: Basic usage of U-Remo

a television. The increasing availability and accuracy of eye gaze detection equipment has encouraged its use for investigation and control applications. Novel methods have also been presented for navigating and inspecting extremely large images solely or primarily using eye gaze control [2]. The advantage of gaze operation compared with gesture recognition is that major body movements are not required. However, a disadvantage is that it is necessary to wear a device, such as glasses, to achieve sufficient accuracy in practical implementations for the remote control of appliances. Some commercial products also employ voice operation, including the Daiseikai VOICE¹ series air conditioner (TOSHIBA).

Various products are based on gesture operation,

¹http://www.toshiba.co.jp/living/air_conditioners/pickup/edr/

²<http://ctlg.panasonic.com/jp/bd-dvd/bd-dvd/portable-tv/DMP-HV200.html>

including a television (DMP-HV200²) produced by Panasonic, where the remote control of TV channel selection and volume adjustment are facilitated by the detection of the user's hand gestures by two infra red sensors at the top of the television screen. FreeDigiter [3] is another interface that allows the rapid entry of digits using finger gestures. An advantage of operation based on gestures and sounds is that appliances can be controlled without a device. However, the user has to remember the correct words or gestures to trigger the desired operations.

Some device-free methods use hand recognition and projection onto the user. For example, PALMbit [4] projects an operation menu onto a user's palm and responses are selected from the user's menu via finger recognition. Skinput [5] is a wearable bio-acoustic sensor, which appropriates the human body as an input device. Vatavu [6] made a system that projects additional controls and widgets onto the wall near the television, although this system is not device-free. An advantage of operating via projected images is that it is easy to understand how to operate the system because prompts are projected. A disadvantage is that the projector tends to be bulky.

U-Remo

In the present study, we developed a prototype remote control device called U-Remo using a depth camera and a projector, which was embedded in an air conditioner unit. The U-Remo system projects graphical prompts onto the user's body, detects the user's hands gesture via the depth camera, and provides visual feedback onto the user's body. The recognized gesture is used to control the air conditioner. The user does not need to hold or wear a device.

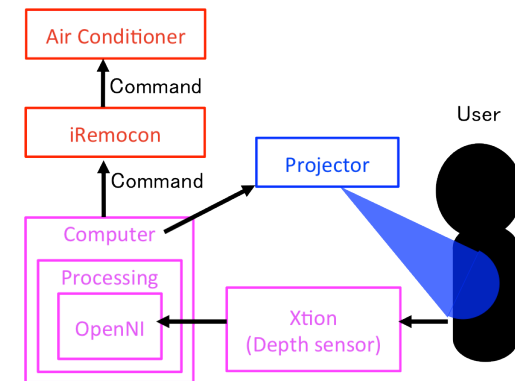


Figure 2: System architecture

Among the possible device-free methods available, we selected gesture operation because it is facilitated by the inexpensive depth camera components found in Microsoft's Kinect. As mentioned above, one of the difficulties of gesture operation is that a user has to learn and remember the gesture. Thus, the projection of graphical prompts helps users to learn and remember gestures.

Projection-based interaction tends to be bulky because of the size of the projector and the requirement for projection surfaces such as a wall, table, or floor. However, the bulky size of the projector can be overcome by using LED or laser light sources. We also designed our system so it could be projected onto the user's body instead of the walls or floors, which are not always suitable in actual rooms. Projecting onto a user's body also has the advantage that the projector can be combined with a depth sensor, which has an identical optical alignment. This makes the overall system compact and allows the possibility of

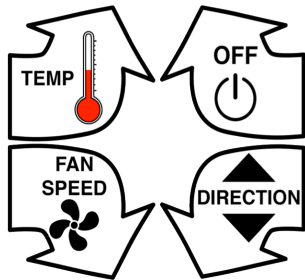


Figure 3: Main menu with four function components

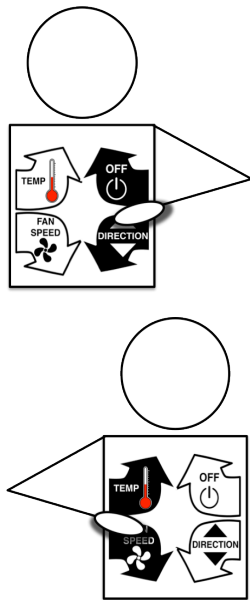


Figure 4: Gestures in the main menu

embedding in home appliances and electronic devices to reduce the production and maintenance costs.

Implementation

The U-Remo system uses the Xtion-Pro (ASUS), the iRemocon (Glamo Inc.), the projector (SONY: VPL-CX86), the air-conditioner (TOSHIBA: RAS-221E) and the PC (Apple: MacBook Air). The Xtion-Pro is a depth camera to measure the depth as well as Kinect described above. The iRemocon is a PC controllable remote-controller for sending infra red light signal to the air-conditioner. It is possible to send remote-controller command from the computer via the network.

Figure 2 shows the system overview. The system projects prompt graphics to the user's body through the projector. Beside the projector, we placed the depth camera (Xtion) to detect user's gesture. Depth images are processed by the middleware of OpenNI, and the Processing language program receives the user's position and skeleton, and it recognizes the user's gesture. Then the program sends commands related to the specific gesture to the iRemocon unit, and it sends infrared signals to the air-conditioner. The information of the user's position and gesture recognition is also used to generate prompt graphics, so that it appears on the user's body and it interact with user's gesture. The content of the prompt graphics is described in the following section.

Application

In this study, we applied the U-Remo system to an air conditioner, which is typically operated using a remote control in the home.

We designed an intuitive and readily understandable gesture system and GUI to operate an air conditioner, as a possible application of our novel method. The gestures can be performed using both hands to improve the recognition performance.

First, when a user stands in front of U-Remo and raises their left hand, the main menu image is projected onto the user's body as shown in Figure 1 and 3. Thus, this hand-raising gesture indicates "Hello." The main menu has four components: (1) ON/OFF for the power supply, (2) temperature adjustment, (3) fan speed, and (4) fan direction. The user can select each function by moving their left or right hand over the main menu image from the left or right side of their body and by moving up or down. For example, as shown in Figure 4 (upper side), the user can operate the power or fan direction functions by moving their left hand from the left side to the center of their body and then moving up (power) or down (fan direction). As shown in Figure 4 (lower side), the user can operate the temperature or fan speed by moving their right hand to the center of their body and moving up (temp) or down (fan speed).

Next, an instruction image is projected onto the user's body after selecting a function, except the power function. Instructive animations are available for beginners or users who cannot remember how to make gestures. Experienced users can ignore these animations and perform the requisite gestures. The main menu can also be skipped before adjusting the temperature and the fan. Therefore, operations can be made rapidly by experienced users. Our system projects step-by-step prompts and provides feedback to gestures on the user's body. Thus, even a beginner can visually recognize the necessary actions.

Power Supply:

As shown in Figure 3, the power switch icon is located on the upper left of the user. Thus, the power toggles ON and OFF when a user moves their left hand to the center of the body and moves it upward. This icon constantly displays the current ON or OFF status.

Fan Direction:

As shown in Figure 3, the fan direction icon is located on the lower left of the user. After it has been selected by left hand's moving down gesture, the user can set the fan direction with fan direction gestures, as shown in Figure 5. The user can set the fan direction from three direction selections by changing the angle of their arm, as shown in Figure 6. Thus, the user can change the angle of their arm to select the appropriate fan angle. The pink arrows in Figure 6 show the directions of the gestures.

Temperature:

As shown in Figure 3, the thermometer icon is located on the upper right of the user. After it is selected by right hand's moving up gesture, the user can set the temperature with gestures, as shown in Figure 7. If the user wants to increase the temperature, they must move both of their hands to the sides of their body and raise both of their hands, as shown in Figure 7 (right). The user performs the gesture in a downward direction if they want to reduce the temperature. The pink arrows in Figure 7 show the directions of the gestures.

Fan Speed:

As shown in Figure 3, the fan icon is located on the lower right of the user. When it is selected from the main menu, the user can set the fan speed with gestures, as shown in Figure 8. Figure 9 shows that the

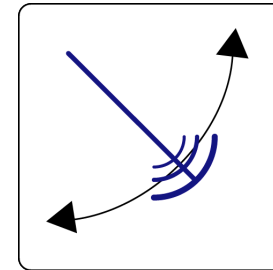


Figure 5: Image prompt for the fan direction

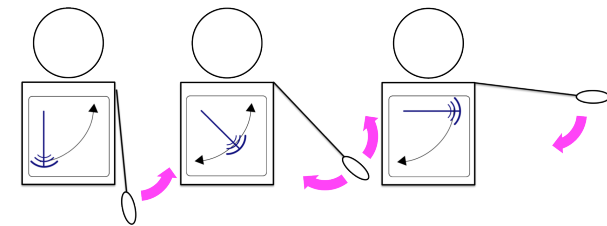


Figure 6: Fan direction gestures

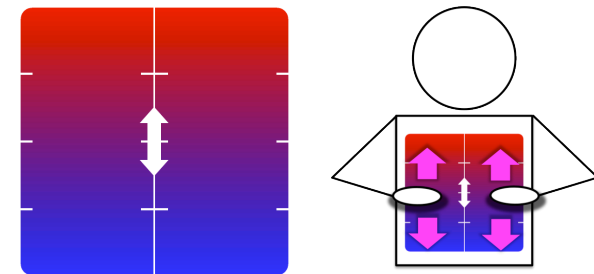


Figure 7: GUI and temperature gestures

fan speed becomes stronger when the user pushes forward with both hands away from the body, thus the fan speed becomes weaker when they position both hands in front of the chest as shown Figure 9 (left).

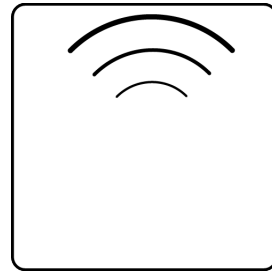


Figure 8: Fan speed GUI

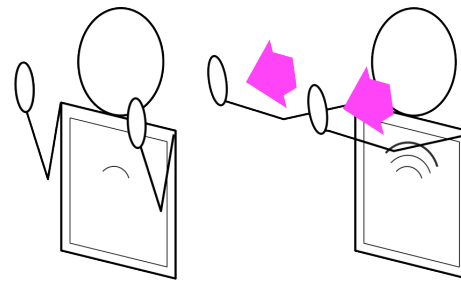


Figure 9: Fan speed gestures

Conclusion and Future Works

In this study, we developed an innovative home electronics remote control method called U-Remo. This method employs user gestures to control gesture prompts, which are projected onto the user's body. We also produced a prototype air conditioner control system based on the U-Remo method.

In addition, we have conducted the performance evaluation of the U-Remo system with four people (age: 20-33 years, height: 155-175cm) and we found that our system have been operated just only providing a brief description. As the future works, we plan to

conduct usability tests by actual users from children to elderly person in a real house. And we will also apply our method to various types of home appliances and electronic devices besides air conditioners to explore the innovative control interface.

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