Home Outlet and LED Array Lamp Controlled by a Smartphone with a Hand Gesture Recognition

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***Abstract*-- In this paper, we design a home outlet and a LED array lamp controlled by hand gesture recognition with a smartphone that has a system composed of two parts: a smartphone's application and a wireless remote control unit (WRCU). The application can read the accelerometer and gyroscope in a smartphone by means of hand gesture recognition and send a control command to the wireless remote control unit. The wireless remote control unit can decode the received message and echo the corresponding action. This design incorporates a LED array lamp as the home outlet used to control both the on/off function and the dimming function.**

I. Introduction

In recent years, the remote controller no longer meets the needs of the users to detect gesture. Therefore using wearable devices with control outlets has gradually become a new method. A previous paper proposed a device which coupled both Bluetooth and infrared sensors with a smartphone to sense arm movements in order to control outlets, so that the disabled user by waving his arms can easily replace the previously popular actions of a finger touching a smartphone [1].

Today's video games often use a camera to intercept the player's actions, and use image processing to achieve accurate motion recognition. The advantage is that players do not need to wear any equipment, but the disadvantages of these games are that they are expensive and do not easily identify multiple users [2].

Some researchers have focused on smartphone gesture recognition, because there are many sensors that are built into smartphones. Through the infrared component and gestures detected by a smartphone, it is easy for a user to control both a home's lighting brightness and its infrared outlets [3].

This design can control the power line outlet and LED array lamp by using the built-in accelerometer and gyro sensors of a smartphone by means of the hand gesture recognition software module. Since a smartphone is commonly used in daily life, an user doesn't need to carry a remote controller. Instead, one just holds a smartphone and rotates the smartphone to control any home outlet and any LED lamp.

II. Hardware Architecture

This design is composed of two parts: a smartphone's application and a wireless remote control unit. A smartphone's application reads the data from the built-in accelerometer and gyroscope and provides the required hand gesture recognition. The application will detect a user's hand gesture such as a rotating or a flipping movement that will dim the LED array lamp or switch the power on/off. The sensor and wireless remote control unit is composed of a NFC coil, a microcontroller unit (MCU) and a Bluetooth transmission module. The NFC tag, which is embedded in a LED array lamp, stores two numbers: its ID number and its Bluetooth MAC address. The system will automatically pair the Bluetooth module by putting the smartphone close to the NFC tag. The system architecture is shown in Fig. 1.

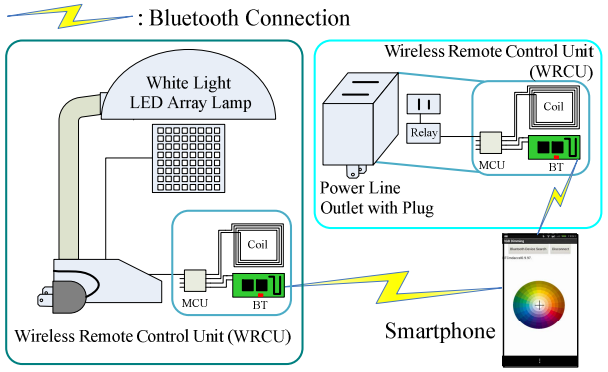

Fig. 1. The hardware architecture.

An user can not only control the LED array lamp, but also control different devices by using hand gesture recognition. This design includes the control mechanism for a power line outlet. As the outlet has a NFC tag, an user can use the same hand gesture to control a device by just inserting plugs into this power line outlet. However, because of restrictions prohibiting any modification to this electrical equipment, this design can only control whether the power line outlet is on or off.

III. Application Software Architecture

Fig. 2 is a flowchart of an application in a smartphone used for hand gesture recognition. When a user activates this application the smartphone will scan a NFC tag which is on the outlet the first time it obtains the Bluetooth MAC address that is already stored in the tag. Therefore, the Bluetooth creates a connection path between the smartphone and the outlet.

There are two types of dimming modes: one is the white light LED dimmer; the other one is the colorful LED light adjustment mode. When a user chooses the "white light LED dimming mode" in this application, the smartphone will start the extraction of the rotational angle information, by using the

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gyroscope to catch the rotation angle to decide whether to turn off or to dim the LED light. When the rotation angle is equal or less than 0 degrees the power will turn on. If the angle is large or equal to 180 degrees the power automatically turns off. Otherwise the white light LED will follow the rotation angle to adjust the brightness.

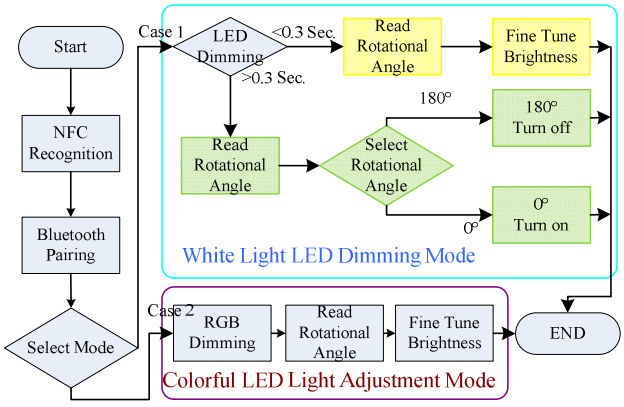

Fig. 2. The smartphone application software flowchart.

If the user picks the "colorful LED light adjustment mode" in this application, three primary colors, consisting of Red, Green and Blue lights, will mix together. This design has established a round color palette which follows the tilt angle along with a smartphone to change the color, including the oblique direction angle.

Fig. 3 (a) shows this design power line outlet and Fig. 3 (b) shows that the detection of the hand gesture with the smartphone is utilized in order to control the LED array lamp, the Bluetooth, coil, MCU and relay package in the outlet. The smartphone can control the circuit board to turn the power line

(a) The power line outlet (b) LED array lamp

Fig. 3. The power line outlet and LED array lamp

outlet on and off.

When selecting the RGB dimming choice from the application, the smartphone will pop a round palette that has a cursor which varies in keeping with the smartphone tilt angle. When a user moves the cursor to the desired tilt specified color block, the LED array lamp color will follow the tilt angle to change the color.

The LED lighting control follows the position of a user's hand, when the user holds a smartphone in his hand. For example: when the user's hand moves up the LED array lamp will turn on; when the user's hand moves down the LED array lamp will turn off. If the user pushes the screen of the smartphone and when holding it, makes a horizontal rotation, the LED array lamp brightness can be adjusted according to the inclination angle.

IV. Implementation Results

Table I shows the power consumption of each module in the receiver unit. When the relay works with the outlet, the relay power is greater than the Bluetooth module. When the outlet works, the maximum power consumption will be the Bluetooth module.

TABLE I
Power Consumption in Each Module

		Stand by	Operation
Outlet	MCU	20 mW	20 mW
	Bluetooth	30.01 mW	85.9 mW
	Relay	16.6 mW	375 mW
LED Lamp	MCU	20.5 mW	20.5 mW
	Bluetooth	30.01mW	86.1 mW
	LED array	0 W (Turn off)	7690 mW (Turn on)

Table II shows the results after the experiment was conducted a hundred times. When the design detected the "turn on" hand gesture, The LED array lamp turned on LED 96 times. And when a "turn off" gesture was also made a hundred times the LED array lamp could successfully be turned off 95 times with an error rate of 5%.

V. Conclusion

TABLE II
Accuracy Rate of the Experiments

	LED array lamp on	LED array lamp off	Recognition error	Accuracy rate
Turn-on	96 times	0 time	4 times	96 %
Turn-off	95 times	0 times	5 times	95 %

This design successfully uses a smartphone to recognize a user's hand gesture to provide the two functions which are necessary to control the LED array lamp and power line outlet. Not only an adjustment of the brightness of the white light but also a conversion of the LED from a white light to a color light can be carried out in keeping with the user's hand gesture. The smartphone hand gesture control power line outlet is suitable for the common smartphone user who does not need to understand the complexity of the connection procedure by automatically pairing the NFC tag to create a Bluetooth communication channel.

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