Home Appliance Control by a Hand Gesture Recognition Belt in LED Array Lamp Case

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***Abstract*—in this paper, we design a wearable appliance gesture remote controller that is composed of two parts: a hand gesture recognition belt and a receiver unit. The controller uses both an accelerometer and a gyroscope to discern hand gestures and a Kalman filter to reduce some jitter noise such as an individual's hands that are trembling slightly. The receiver unit can decode the received information and echo the corresponding action. This design incorporates an LED array lamp as the home appliance used to control the on/off function and the dimming function.**

Keywords—Kalman filter; gesture; appliance control; LED array lamp

I. Introduction

A study describes the method used to identify the approach of a human. There is a "two-stage" action used to detect any related arm gesture. The system uses a wearable inertial sensor to recognize both human eating and drinking actions. It establishes Euler angles in a three-dimensional space and classifies a high-precision detection algorithm to obtain varying characteristics present during a specific period of time [1].

Another article proposes a 3D gesture system which uses an accelerometer chip to obtain continuous data that can be transmitted via Bluetooth communication to the host. The host side, after receiving any data will analyze and decode them to become a specific operation command [2]. A researcher uses a real-time depth camera with infrared pulses of variable frequency and duty cycle to reconfiguration gesture for the special case of a car control [3].

In this paper, we have designed a wearable device which is composed of a three-axis accelerometer, a gyroscope, a micro control unit (MCU) and Bluetooth communication modules. The accelerometer and gyroscope combination are on a module and continually send out data. The MCU obtains both the data and the human hand shaking acceleration signal by using a Kalman filter. The system, by means of a comparison of each hand moving characteristic value determines the hand gesture. Finally, the control command, by means of Bluetooth communication modules transmitted controls the home appliance on/off function.

Fig. 1 shows our control method. The left side of Fig. 1 represents a controlled LED array lamp; the right side of Fig. 1 represents a user who is wearing a hand gesture recognition belt (HGRB) on his hand. When he swings his hand up or down, the LED array lamp will turn on or off. As a result of the user's palm shaking either to the left or to the right, the brightness of the LED array lamp can be dimmed [4].

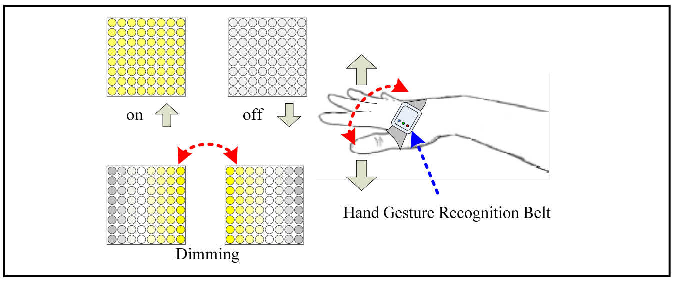

Fig. 1. The user's hand gesture which can control the LED array lamp.

II. Hardware Architecture

The wearable appliance gesture remote controller (WAGC) is composed of two parts: the hand gesture recognition belt (HGRB) and the receiver unit, as shown in Fig. 2. The HGRB is a master device which can recognize the user's hand gestures and decode them, so they will become a control command. The receiver unit needs an additional MCU, Bluetooth module and some solid state relays (SSR), all of which are used to control the home appliance on/off function.

The HGRB is tied to the hands. When the system is reading the accelerometer and gyroscope value, any hand movement becomes a very obvious noise. As there may be much white noise in the measurement signal, in this design, we add a Kalman filter; by means of an iteration algorithm, whose function are both to calculate and to suppress the white noise, we are able to improve the recognition rate of identifying hand gestures.

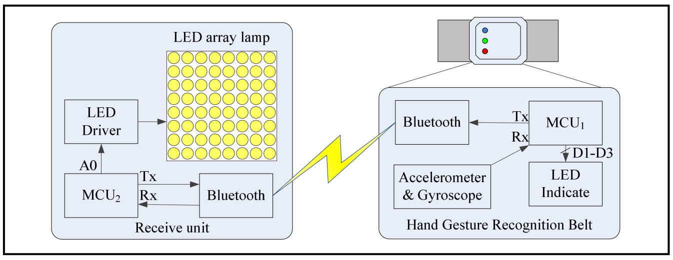

Fig. 2. The WAGC architecture.

III. Software Architecture

Fig. 3 is a hand gesture detection flowchart. A user wears the HGRB and is ready to detect hand gestures, the sensors will read out a rotation signal to signify when the HGRB is in the ready state. Then the system wakes up HGRB by clicks the surface of the device. The number of click times decides the detection actions. A two click will result in beginning Procedure A and three clicks will result in beginning a procedure B. Procedure A detects the rotation angle and the direction of motion. Procedure B only detects the rotation angle.

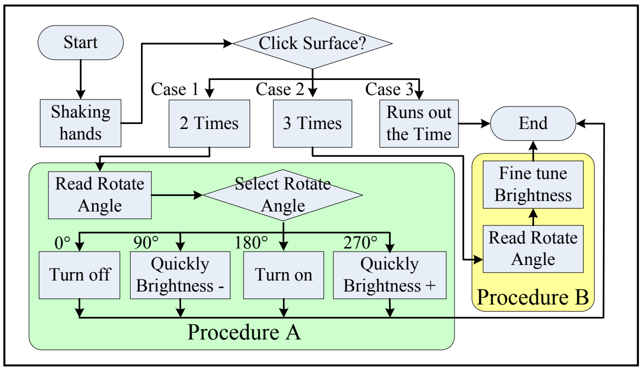

Fig. 3. The hand gesture detection flowchart.

Procedure A detects the palm rotation angle and the hand moving direction. The system will determine the palm rotation angle and then make sure the palm faces forward to the correct direction. The next procedure converts those actions to instructions, such as "turn on", "turn off", "quickly increase brightness" and "quickly decrease brightness". The procedure B only detects the palm rotation angle. The system will determine the angle of palm rotation and transform those actions in order to fine tune the brightness instruction.

IV. Results of Experiment

Table I is a comparison table of our design and other designs. Design A uses a smartphone with custom application software as a remote controller. Design A uses Wi-Fi protocol to transmit control command to receiver which then turns the LED lamp on/off. Design B, which is similar to design A, uses Bluetooth protocol as transmission media and switches the home appliance on/off by a controller. Our design uses a wearable device through the Bluetooth transmission to control a LED array lamp.

TABLE I. Comparision with other design

	Design A[5]	*Design B[6]*	*Our Design*
Communication mode	Wi-Fi	Bluetooth	Bluetooth
Remote unit	Smartphone	Smartphone	Wearable device
Controlled device	LED lamp	Home appliance	LED array lamp

Fig. 4 shows that this design, which includes a Kalman filter, can easily determine the hand rotation angle by smoothing the input signal from the three-axis accelerometer and gyroscope. The top of Fig. 4 presents the three signals during the change states such as "stationary state", "palm flip 180 degree rotation" and "hand waving upward" and the bottom of Fig. 4 shows the corresponding hand gesture.

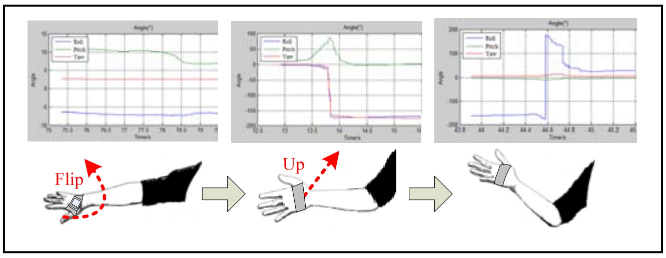

Fig. 4. The relationship between the hand and the sensor signals

Table II shows the power consumption of each module in the system. The Bluetooth module consumes more energy in the HGRB's operation mode.

TABLE II. Power consumption in each module

	Power consumption of each modules	
	Stand by	***Operation***
1. HGRB		
Accelerometer and gyroscope	15.50 mW	36.50 mW
Bluetooth	29.37 mW	85.8 mW
MCU_1	19.8 mW	19.8 mW
2. Receiver Unit		
Bluetooth	30.17 mW	86.2 mW
MCU_2	20.1 mW	20.1 mW
LED array	0 W (Turn off)	7730mW (Turn on)

V. Conclusion

This design provides a sufficiently accurate rate of hand gesture recognition by using the Kalman filter. In addition, this device is small and consumes less power. In the next stage of development, the HGRB can be replaced by a smartphone and then recognize the hand gesture by means of the smartphone.

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