Gesture Based Automating Household Appliances

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Abstract. Smart homes can be a potential application which provides unobtrusive support for the elderly or disabled that promote independent living. In providing ubiquitous service, specially designed controller is needed. In this paper, a simple gesture based automating controller for various household appliances that includes simple lightings to complex electronic devices is introduced. The system uses the gesture-based recognition system to read messages from the signer and sends command to respective appliances through the household appliances sensing system. A simple server has been constructed to perform simple deterministic algorithm on the received messages to execute matching exercise which in turn triggers specific events. The proposed system offers a new and novel approach in smart home controller system by utilizing gesture as a remote controller. The adapted method of this innovative approach, allows user to flexibly and conveniently control multiple household appliances with simple gestures.

Keywords: Gesture, smart home, stand-alone server, flex sensor, deterministic algorithm, remote controller.

1 Introduction

Generally, smart home (or commonly known as home automation and domotics) is a home equipped with various sensors, actuators and other technology that assists its resident in performing daily activities [1]. Assistance is done using various integrated hardware devices and software application which provide ubiquitous services. As computer technology advances, current smart home systems have transited from centralized one-system architecture to loosely-coupled distributed one. It is composed of cooperative agent that integrates heterogeneous ubiquitous computing in providing services [2].

In providing ubiquitous service, smart home uses various types of controllers to control household appliances. The smart home controller is the most important element in a smart home environment as it provides both controls and gateway between users and household appliances [3]. Occasionally, the gateway are connected to the home network; composed of communications with household appliances such as broadband modem, router, PCs, wireless access point, entertainment peripherals,

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and other electronic devices. It allows users to control household appliances remotely through the external network like Internet or mobile network.

This paper presents a new approach in controlling household appliances by using gesture based controller. A gesture based recognition system reads the gestures produced by the signer. The controller is able to control from simple to complex household appliances that in turn to triggers required event. The adapted method for this approach allows user to flexibly and conveniently control multiple household appliances with simple gestures.

The outline of the paper is as follows. Section 2 presents an overview of smart home controller research. The proposed framework by using gesture based is described in Section 3. The performance evaluations are discussed in Section 4 and finally this paper is concluded in the last section.

2 Smart Home Controller

Efforts from researchers mainly focus on technologies and existing standards in integrating a centralized smart home controller that could control the connected devices and services. Results from this effort show that controller needs to be easy to handle, lightweight, and have more intuitive interface for people to interact with all the devices at home [4].

An investigation in [5] shows that people often prefer to use smart phones rather than the computers at home, as they are easily accessible and convenient to use. Moreover, touch screen based interaction is becoming prevalent in smart home. Utilizing these characteristics, various researches concentrates on creating smart home controller using smart phone or touch screen technologies. Some of the popular research can be seen in [4] called HouseGenie. The HouseGenie is a universal monitor and control of networked devices in smart home using common touch screen phone. By wirelessly communicating with an OSGibased portal, which maintains all the devices through varied protocols, HouseGenie facilitates universal home monitor and control. Figure 1 shows a glance of HouseGenie system.

(a) (b)

Fig. 1. Glance of using HouseGenie in smart demo home based on (a) Android on Nexus One, and (b) Windows on Vivliv S5

Voice controller can also be applied in smart home environment. User could voice out command that allowed sound controller to distinguish the word, in turn triggering certain events. One such application can be seen in [6]; where the controller applied speech recognition library provided by SUNPLUS in identifying the command. The system captures the voice command pronounced by the user, parsing it and sends a control message to the home network that operate respective appliances.

A unique method has been proposed in [7] by using thoughts in controlling home appliance. By capturing certain level of electroencephalogram (EEG) or electrical brain activity, control commands could be given out in switching TV channels, opening and closing doors and windows, and navigation. EEG is captured by using special control masks that communicate with brain-computer interface (BCI) system. This method is currently tested only in smart home simulation but the possibility of applying it in real life may be realized in the future.

3 Gesture Based Controller (GaC) System Model

The gesture based controller (GaC) is a new method in controlling various household appliances by using simple and easily memorize gesture. GaC uses a glove based approach in recognizing the gesture produced by the user. In this system the user is required to wear a specially made glove that allows GaC to read commands from the user. The GaC framework can be divided into three main components as shown in Fig. 2; the gesture based recognition (GBR) system, data processing center (DPC) server and the household controller unit (HCU).

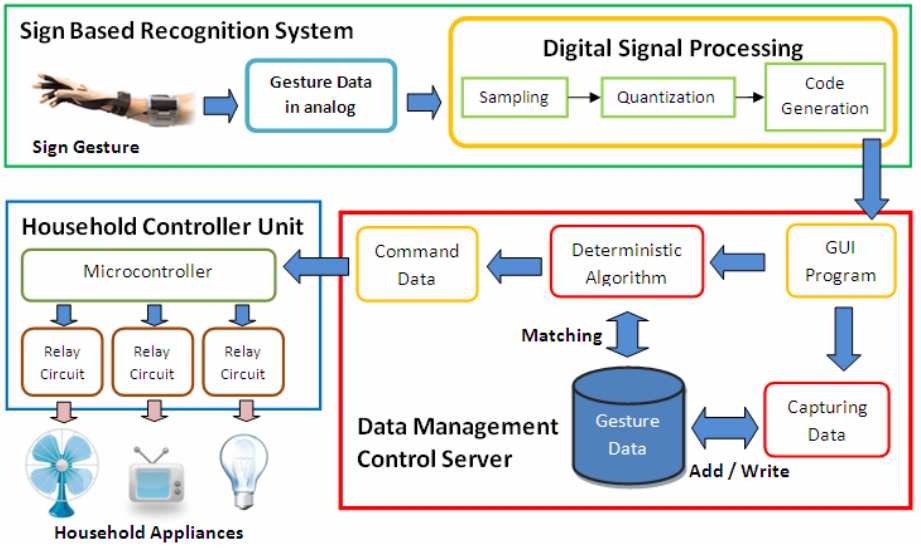


Fig. 2. The proposed framework of GaC for automating household appliances

The GBR system captures gestural input performed by the user and transforms it into digital data format or codeword. The digitized codeword data are then transmitted to the DPC server by using transceiver system. DPC performs a simple deterministic algorithm on the received codeword data to execute matching exercise. Once the matching exercise is determined, a control or command data is transmitted out to the HCU where required event is triggered.

3.1 Gesture Based Recognition (GBR) System

The GBR system is a wearable data glove system that recognizes gestures produced by a user or signer. It produces codeword data which represents the gesture produced by the signer. Gestural input are captured using flex sensors which are attached on top of each finger. The flex sensor is a resistance-varying strip that increases its total electrical resistance when the strip is flexed in one direction.

The function of the sensor is the same as a simple potentiometer capable of changing its resistance by twisting the potentiometer's knob. Voltage of the circuit is directly proportional to the resistance as given by Ohm as follows:

$$V \alpha R \tag{1}$$

The varying changes of the resistor in turn change the voltage accordingly. By using the concept of voltage divider, V_0 represents the needed data for recognition purposes and that point is connected to the microcontroller as shown in Fig. 3. A total of three processes are done during digital signal processing (DSP); sampling, quantization and code generator. Fig. 4 displays the flow diagrams of DSP. In the process of sampling, the analog data are read at specific time interval. As for quantization, the obtained values are translated into discrete values. The maximum discrete value depends on the number of bits that can be supported by the microcontroller. The code generator process is a process that converts the quantized value into appropriate data value for transmission. Once the conversion process has been done, the codeword data is transmitted to the DPC through a transceiver system. The Bluetooth system has been selected as the transceiver system for this experiment.

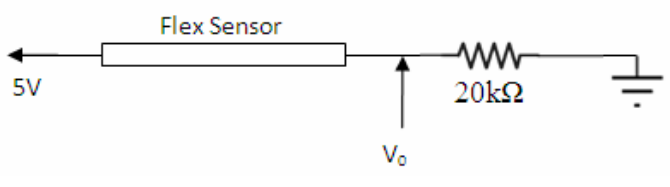


Fig. 3. Flex sensor interfacing with the microcontroller

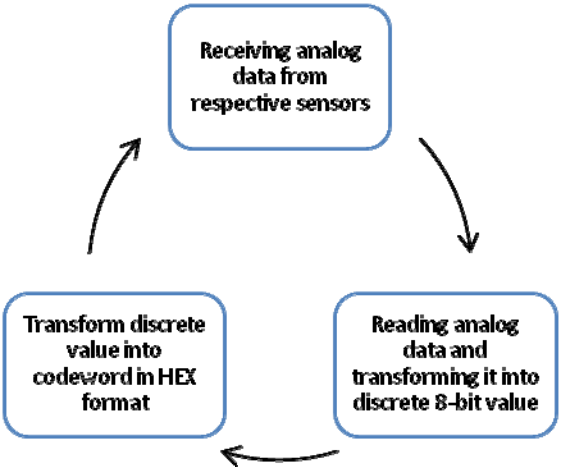


Fig. 4. The DSP flow diagram of GBR system implementation

3.2 Data Processing Center (DPC)

The data processing center (DPC) is resided on a standalone server or a computer to provide deterministic process in recognizing and determining the codeword data. A graphic user interface (GUI) program has been developed that allow user to select two of the main functions of the system; the activation function and the edit function. The activation function provides the necessary command data that is corresponding to the codeword data produced by the user. A simple matching algorithm is used on the codeword data and gestural data to produce the required command data. Matching is achieved when the codeword data is matched with one of the gestural data stored in the database. The produced command data contains the necessary information required in triggering events to the household appliances. The edit function allows user to redefine the gestural data with a new one. This is done by capturing the new gestural data and replacing it with the old gestural data.

3.3 Home Controller Unit (HCU)

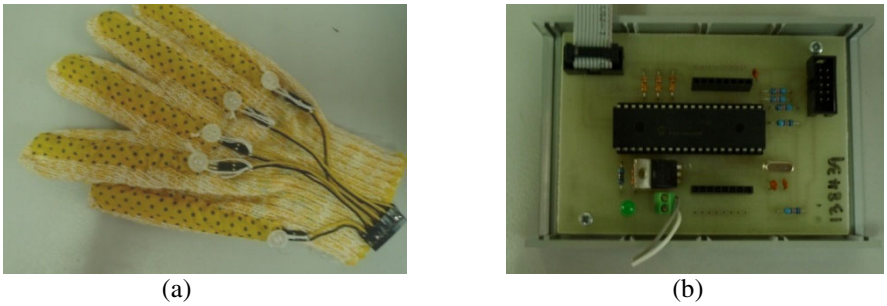
The home controller unit (HCU) plays the role of controlling the household appliance according to the received command data from DPC server. By combining microcontrollers and relay circuits, simple on/off function can be performed on the electrical appliances. The relay circuit is turned ON when it receives a high input from the microcontroller and turned OFF upon receiving a low input. Moreover, communication between the HCU and DPC server is done using either serial or wireless communication. Again, Bluetooth is selected as the transceiver system in this set up.

4 Results and Discussion

The system is tested in a small scale environment consisting of five simple household appliances. Each household appliance requires two command data to operate a simple on/off scenario. Therefore, a total of ten sets of gestural data are needed in this experiment. Before the experiment begins, DPC is first 'trained' to recognize the ten sets of gestural data. Fig. 5 shows ten examples of command data that can be used by a single glove.

Fig. 5. Example of possible gestural command data

As seen in Fig. 5, each gestural data is unique to each other. The system is designed as such that each distinct gestural data is corresponding to a command data that could control the household appliances. In order to read the gestural input, users (or signers) must wear GBR as shown in Fig. 6.



(a) (b)

Fig. 6. Gestural based recognition (GBR) system with developed (a) data glove and (b) control circuit

DPC allows user to 'train' the system by selecting the edit function as shown in Fig. 7. By selecting the corresponding command, a user could train the system using any gestural input. Once the 'training' is complete, the system is ready to be used by selecting the activation function from DPC.

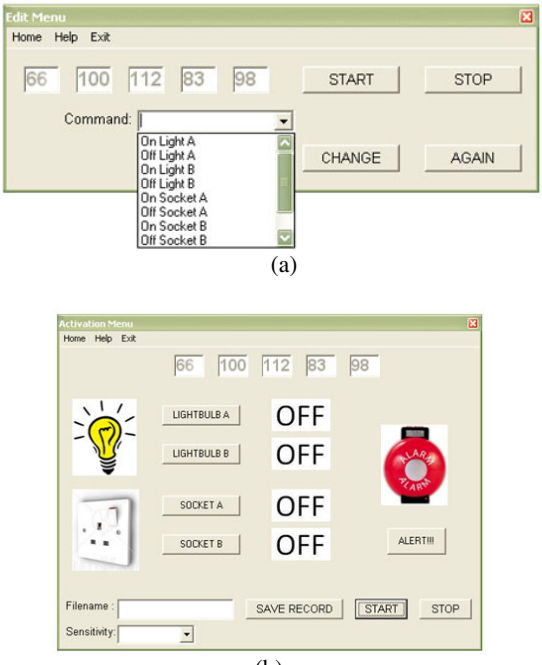
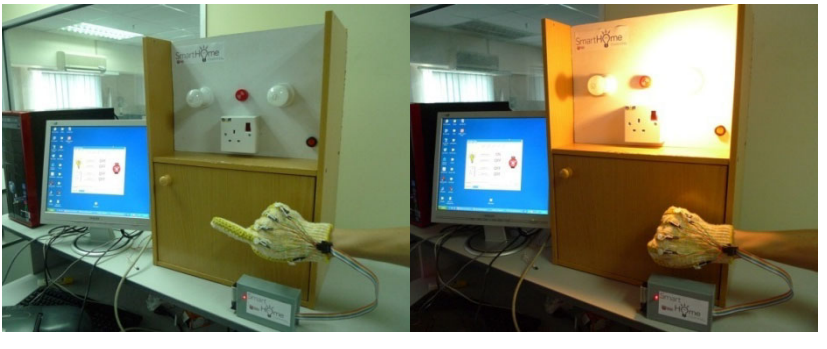


Fig. 7. A developed GUI in DPC server with (a) the edit function and (b) the execution / activation function

The command data is produced by DPC by using deterministic approach where a matching algorithm is done on the codeword data. An example can be seen in Fig. 8 where two examples of gestural data are used in controlling one of the household appliances.



(a) (b)

Fig. 8. Operation of the system where the light bulb is (a) turned 'OFF' and (b) turned 'ON'

In addition to the executing of the required function, the system has been tested on its flexibility in allowing user to change the gestural data. This is done by capturing the new gestural input produced by user and stores it in the database, replacing the old gestural data. This characteristics and ability allows user to freely and flexibly change the gestural data into one that is recognizable or easily produced by the user. It is helpful to user especially disabled people that could not perform certain gestures freely. Fig. 9 shows an example of changing a corresponding gestural input to a new input.

(a) (b)

Fig. 9. Examples of editing gestural input of light bulb from sign (a) to sign (b)

The proposed system offers a new approach in smart home controller system by utilizing gesture as a remote controller. The adapted method for this innovative approach allows user to flexibly and conveniently control multiple household appliances with simple gestures. Additionally, the system is built using low-cost approach that could be implemented easily onto any household.

Overall, the whole system is not a perfect controller as it comes with a number of limitations. One of the hurdle is determining when the user is addressing the system; especially the GBR system. This skill is beyond the current sign based recognition glove systems that is available in the market. Therefore, the application program must allow users to inform the system that the GBR is being addressed. Additionally, the system must be smart enough to determine when the system is idle when not in used.

Additionally, the GBR and DPC system requires additional improvement on the recognition algorithm. Currently, the system implements a simple matching algorithm which could only support simple gestural recognition. For advance recognition, it is required to have better sensory and algorithm.

Furthermore, the system can be further improved by eliminating the need of data glove. This can be substituted by using visual-based gesture translation system that provides gloveless system. As its name indicated, visual-based system that uses visual recognition can be employed in acquiring the expression and gestural movement of the signer. It requires three main stages in translating the gesture; video acquisition, video processing and lastly the translation process. Some examples of visual-based translation can be seen in [8], [9].

5 Conclusion

This paper presents a new and alternative approach in providing controller to a smart home system using gesture. The proposed method uses a data glove to translate and capture gestural input of the user. By using deterministic approach in translating and parsing the gestural input, user could control from simple to complex home appliances. Additionally, the system has been designed to be flexible, in which it allows user to freely change the gestural input corresponding to a command data. However, the proposed scheme comes with certain limitations i.e. to determine when the system is being addressed and sensitivity issue. Improvements can be further done by introducing visualization instead of using data glove. Future works would include improving its accuracy and sourcing cheaper methods in capturing the gestural data.

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