A Smart Power System

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Abstract. As smart building becomes increasingly popular, it enables many interesting applications, such as smart lock, elderly monitoring and remote healthcare. This paper will introduce one sub-system in the smart building: smart power system. This smart power system consists of an Android application, a cloud server and a smart socket. In addition, human-device interaction methods in this system are studied.

Introduction

Smart home and smart appliances are main application areas of Internet of things. In recent years, smart home system becomes popular in the market. Refrigerator, for instance, can send a message to user when it is almost empty.

In order to enable users to remotely control devices, a smart power system is proposed in this paper. An android application in the mobile phone is the central controller in the smart power system. Bluetooth is used to connect the Android application to the smart socket. Users can control smart sockets using their mobile phones.

However, the devices, for example our smart socket, cannot interact with users easily due to their sizes. The traditional human interaction devices such as keyboard, mouse and monitor are not suitable for them. Therefore, it is essential to design an effective method which user can interact with smart home devices conveniently.

This paper introduces different kinds of human-device interaction methods of smart home and appliances. Then, a questionnaire is used to interview users. Eventually, these methods are analyzed according to survey results.

The Smart Power System

In this smart power system, the mobile phone is the central controller. It will search for Bluetooth equipment nearby after user sends an instruction. Afterwards, the mobile phone and the smart socket will be connected after Bluetooth paring. In addition, the mobile phone can send data to a cloud server. The cloud server will store and process collected data. Also, a remote client can access the mobile phone and control the whole system via Internet or mobile networks. The design of this smart power system is shown in Figure 1.

When smart power system is used locally, users can control smart socket directly without Internet connection. This is better than users control smart socket locally but with internet [1, 2]; because their system need the cloud server to forward local control messages, which will cause communication delay. The detailed procedure is as follows. (1) Firstly, users open their android application, and send operation messages. (2) After that, the Android application will search and connect to the specified smart socket using Bluetooth. (3) Then the control message can be sent to the smart socket through Bluetooth. (4) Users can also terminate Bluetooth connections.

In the situation of remote access, the mobile phone/home central controller with the Android application should be installed in the home, and this mobile phone must be connected to the Internet. And then, users can use their client side devices to control smart sockets remotely. The control message will firstly be sent to the cloud server, and the cloud server will transmit the control message to specified home central controller. After the controller receives the control message, the

android application will search for the specified smart socket and try to connect it using Bluetooth. After the control message has been executed, the controller will be disconnected from the specified smart socket.5

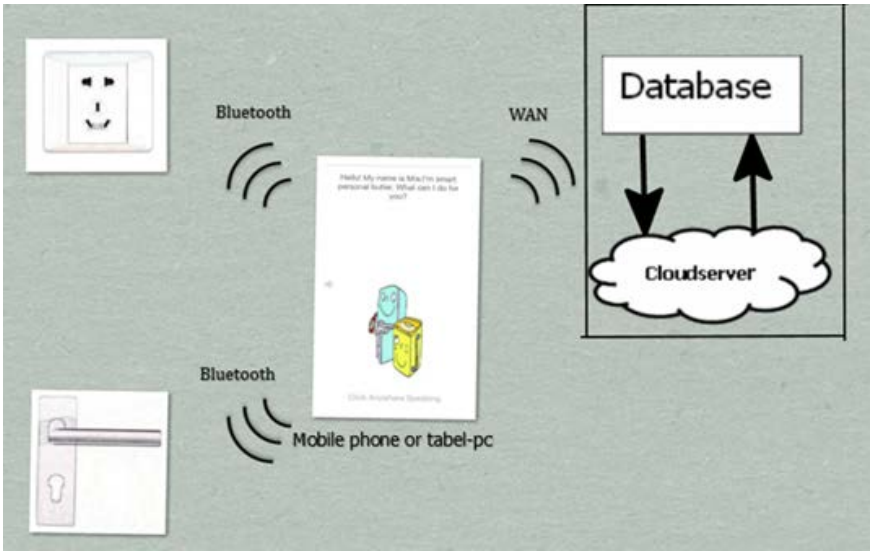

Figure 1. The smart power system.

Human Device Interaction

Human-device interactions between mobile phones and smart sockets are studied here. The interaction can be roughly divided into two procedures: bootstrapping process and feedback process.

Bootstrapping Process. It refers to the process of adding smart sockets to the mobile phone application. Several methods are listed below.

- Manual detection. Firstly, users need to switch to the 'Add Device' interface to add device (Figure 2a). In this function, users can add a head portrait for the device, which can be used when users chat with devices. Secondly, users should give names to their devices. These names will be used when the users control their devices through voice.
- Quick response (QR) code. QR code is a form of matrix barcode technology whose information can be read by scanning itself. As for smart appliances, QR code usually contains a link; users can use it to gather the devices' information.
- Near Field Communication (NFC). NFC is one of the core technologies of the electric tags, which does not require the direct contact with two devices. NFC reader has the capacity to read the information in the short-range distance through wireless interaction [3]. Such kind of tags can be embedded in the smart home system that needs to interact with consumers. Each smart appliance may be installed one electric tag and user can detect them by NFC reader. Furthermore, the special reader will read the relevant data and information from the devices. It should be noted that a variety of smart phones support the NFC technology and the internet of things system may utilize such API to interact with users.
- Voice/speech recognition. Voice recognition, or speech recognition, "is a computer technology that utilizes audio input for entering data rather than a keyboard"[4], which means the language can be recognized and responded intelligently when speak to a microphone. Voice recognition has been used for security issues and it can be used to verify the identity of individuals [5].

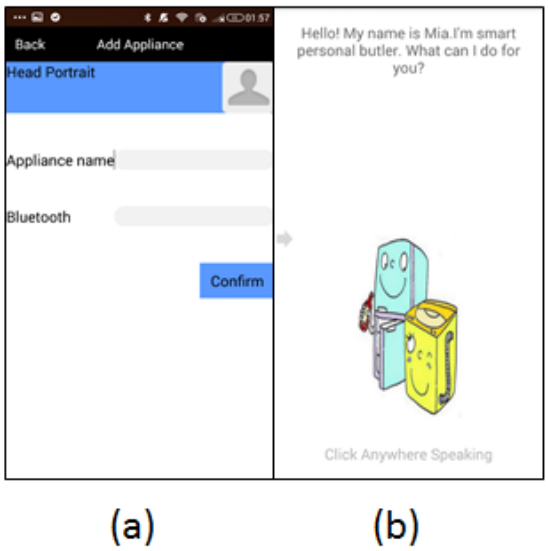

Figure 2 . Manual detection.

Feedback Process. It refers to the process that smart sockets give users some feedback signals. Several methods are listed below.

- LEDs. LED signals work as feedback signals. Different colours are associated with different meanings.
- Sound. Buzzer beeps work as feedback signals.
- Voice/speech. For example, smart socket is able to “talk” to the house owners, thus the house owner can get the devices' state information in real-time as feedback signals.

Survey Design and Results

A questionnaire is designed in order to study the preference of candidates among differnt bootstrapping and feedback methods. 23 people answered the questionnaire. All of them are college students.

They are asked to choose their preferred bootstrapping methods among (1) manual, (2) QR code, (3) NFC, (4) speech, and (5) others. The survey result is shown in Figure 3. It shows that QR code get the highest score, more than 50% candidates prefer this method. Manual and NFC are the 2nd and 3rd choice, respectively.

In addition, candidates are asked to choose their preferred feedback methods among (1) LED flashing, (2) change LED color, (3) turn on LED, (4) buzzer beep, (5) recorded speech, (6) others, and (7) not necessary. As we can see from Figure 4, LEDs, especially LED flashing and color changing, get the highest scores in general. However, in emergency scenarios, buzzer beep gets the highest score, almost 70%.

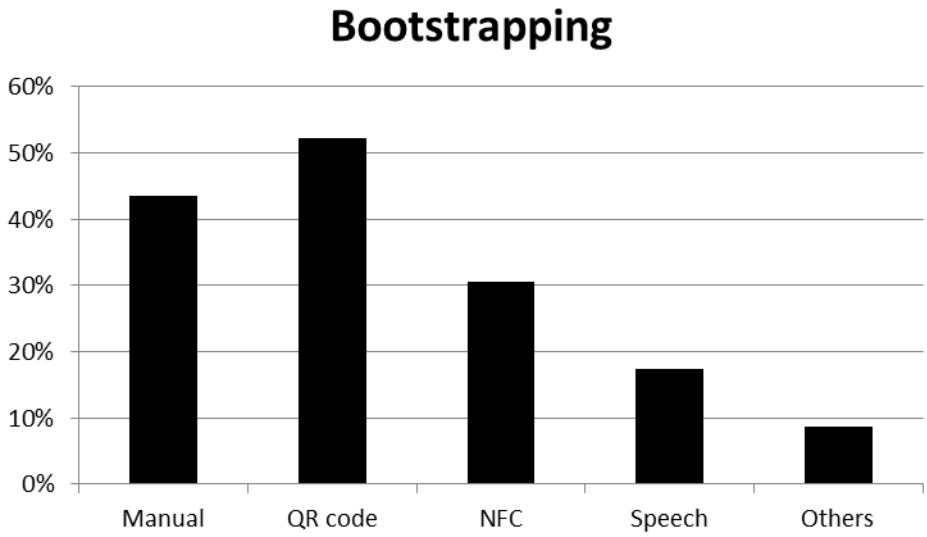

Figure 3. Survey results regarding the bootstrapping procedure.

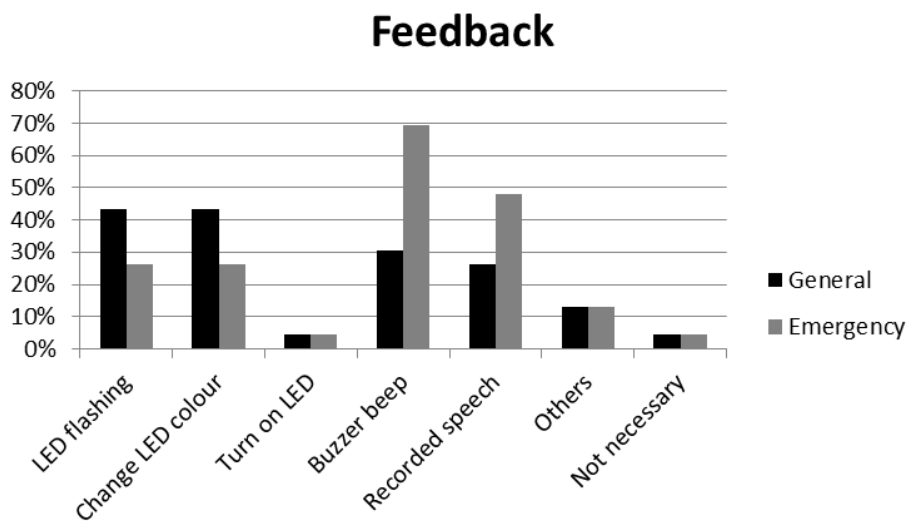

Figure 4. Survey results regarding feedback signals.

Conclusion and Discussion

This smart power system uses android application as the home terminal to achieve the remote control with the smart power regardless of the network connection issues. When the smart power system works in the situation that is not available to the Internet, it uses Bluetooth to form a LAN and thereby achieve the function of wireless control. On the other hand, in wide area network, the control message will firstly send to the cloud server, and the cloud server will transmit control message to specified home terminal, and the home terminal will send control message to the smart power with Bluetooth.

In addition, this paper has firstly described two kinds of human-device interaction processes for the smart power system. Based on our survey results, QR codes and manual operations are the best interaction methods in the bootstrapping process; LED-based signals are the best feedback method in general; and buzzer beeps are the best feedback method in emergency scenarios.

Acknowledgement

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