Point-n-Press: A shrewdly widespread remote Control framework to home Appliances

[1]Chethan yadav T R, [2]Hemanth Kumar A R

[1]M Tech in Digital Electronics and Communication, [2]Professor
Electronics and Communication Engineering,
Bangalore Institute of Technology, Bangalore, India

***Abstract*— The Internet of Things (IoTs) can be described as connecting everyday objects like smart-phones, Internet TVs, sensors and actuators to the Internet where the devices are intelligently linked together enabling new forms of communication between things and people, and between things themselves. With numerous connected devices and appliances, the smart home is one of the representative fields of Internet of Things (IoT). As the complexity of devices/appliances increase, numerous buttons (sometimes dozens) are designed on the remote controller. A user may be confused with the controller even if he or she only intends to perform a simple operation. This confusion also leads to a higher probability of mal operations. To address these problems, an intelligent universal remote control system for home appliances named Point-n-Press is proposed. Point-n-Press addresses the directionality feature, which enables easy and intuitive control by pointing to the target device to display the target's control interface on the screen of the remote controller. This work presents an intelligent universal remote control system for home appliances. A smart phone equipped with infrared (IR) capabilities is easier to realize functions of the Point-n-Press remote controller (PPRC). For implementation of the Point-n-Press control box (PPCB), the design of the small and narrow hole is a trick for the IR mechanism. According to the design of this mechanism, only one device can be simultaneously pointed and controlled by the proposed control system. Therefore, the proposed control system always displays one control user interface of a single device.**

Index Terms— Intuitive control, IoT, less bandwidth consumption, smart home, user-friendly UI

I. INTRODUCTION (HEADING 1)

INTERNET of Things (IoT) [1] is a technology that connects all things and the Internet in smart spaces. By implementations of intelligence with sensing devices, IoT has been widely applied to different fields, such as smart homes[2],[3]. The application fields in smart homes [4] incorporate smartness into home areas for comfort, safety, security, healthcare, and energy conservation [5], [6]. The need for comfort and a convenient life are especially important in smart homes. Thus, home automation is one of the most essential and critical components for the IoT-based smart home technology. Home automation systems are used to control home devices or appliances in smart homes and provide automatic remote control inside or outside homes [7]. Nevertheless, although remote control provides convenience and ease of use, some major problems require consideration and improvement, such as how to provide an intuitive and user-friendly remote control scheme in IoT-based smart homes [8].IoTs technology can also be applied to create a new concept and wide development space for smart homes to provide intelligence, comfort and to improve the quality of life.

The goal of this paper is to develop an intelligent universal remote control system for home appliances called Point-n-Press. Point-n-Press automatically detects the device (or appliance) when a user points the controller at it. Also, a user interface (UI) for controlling this device is immediately displayed on the screen of the controller. Only the functional buttons that are relevant to the current control context appear on the UI. The UI provides intuitive operations and user-friendly interfaces, which enable users to simply enable and control the target device among the increasingly complex functionalities of home devices in a shared space for IoT-based smart homes. Note that a finite state machine (FSM) is used to model all operational states of a device and dependencies among these states.

Two real prototypes are implemented in smart homes to demonstrate the feasibility of the proposed scheme. Fig. 1 shows one of the prototypes for controlling a fan. In this control prototype, Point-n-Press is implemented in a mobile phone; a fan can be directly controlled by pointing to an external control box near the fan. Note that two state dependencies are included in the control process of the fan. First, the fan can only be started by pressing the “Power” button when it is powered off, whereas pressing other buttons is useless.

Second, the “wind speed” button has no effect on the fan when the fan is in sleep or natural mode, because the wind speed is automatically adjusted. Thus, by considering the state dependencies, only functional buttons that are relevant to the current context are displayed on the screen of the controller.

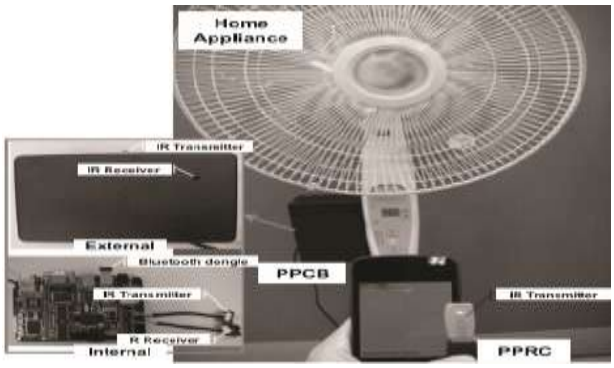

Figure.1. Prototype of the proposed control system for control of a fan.

II. RELATED STUDIES

Currently, the majority of devices and appliances in smart homes are equipped with a remote controller, which includes a number of buttons and wireless transceivers [9]–[11]. This setup provides higher operational complexity around the space with numerous devices or appliances. Thus, the idea of the universal remote controller (URC) is introduced to integrate multiple functions of home devices or appliances into one single remote controller [8], [12]-[14]. Nevertheless, various functions and buttons of a URC results in more complicated operations, the problems of intuition and user friendliness remain.

Numerous solutions are proposed to develop URCs with a liquid crystal display(LCD) screen, networking capability, and several techniques[15]–[17].Typical techniques for these types of URCs include universal plug and play(UPnP)and universal remote console specification of the alternate interface access protocol (AIAP-URC). Built in with these techniques, the device or appliance can be automatically detected via a network [18]–[21],and a UI is dynamically generated from descriptions and properties of the device or appliance[22][24].

Recently, some interaction approaches are proposed to control appliances in smart homes, including the use of voice commands [28] and figure gestures [29]. Nevertheless, the voice control may not work well when the environment is noisy. Additionally, with gesture sensing techniques, users may have to guess or learn the control gestures of the appliances that are probably not natural and intuitive. Besides, an interactive television with a beyond-screen interface is introduced to provide intuitive interactions for controlling TVs. The system focuses on interacting with TVs and does not consider the directionality of IR and the state dependencies of the device operations. All icons for the control features, which are displayed on the screen of the controller, may confuse users.

III. PROPOSED SCHEME OF PONIT-N-PRESS

Here, the comprehensive system architecture and its primary components and the detailed work flows of the proposed Point-n-Press.

1.System Architecture

The architecture of Point-n-Press consists of two parts: 1) the Point-n-Press remote controller (PPRC) and 2) a number of target devices, which embed in the Point-n-Press control box (PPCB) for interacting with the PPRC, as shown in Fig.2.

The functions of the components in the PPRC are described as follows.

- Interface Generator creates a UI according to the properties and descriptions of the target device and its current state
- Device Profile Registry stores the information of the current target device, such as its current state and dependency between each state.
- URC Control is the main component of the PPRC, which is responsible for receiving DCPs from target devices. The URC Control subsequently analyzes the DCP and the current state of the target device to perform additional control operations.
- UPnP Control Point is a set of network protocols that enables networked devices to seamlessly discover each other in the network and establishes functional network services for communication. The UPnP Control Pointis applied to transmit the control commands to target devices.
- Android platform is the operating platform of the PPRC, which is Linux-based.
- Underlying communication interfaces are used between the PPRC and the target devices, including IR, ZigBee, Wi-Fi, and Bluetooth. A gravity sensor (G sensor) is utilized to detect the movement of the PPRC. An IR transceiver is used to detect and identify a certain target device as the PPRC is pointed to a specific target device.

Each target device, which is controlled by the PPRC, is composed of two parts: (1) the PPCB and (2) the home appliance. Note that even a non UPnP conventional and legacy appliance with IR capability can be adapted and controlled with the proposed control system via the PPCB mechanism. The functions of the components in the PPCB are detailed as follows.

- Device Control Profile is a file that specifies the properties and descriptions of a target device.
- Target Control generates DCPs and transfers the corresponding DCPs to the URC Control of the PPRC.

- UPnP Device communicates with the UPnP Control Point of the PPRC and executes the received UPnP control commands.
- Linux platform is applied as the operating platform of the PPCB.
- Underlying information communication interfaces use an IR transceiver to receive a detection signal from the PPRC when the PPRC is pointing to the IR transceiver of the PPCB. ZigBee, Wi-Fi, and Bluetooth can also be utilized as the communication interfaces between the PPRC and the target devices.

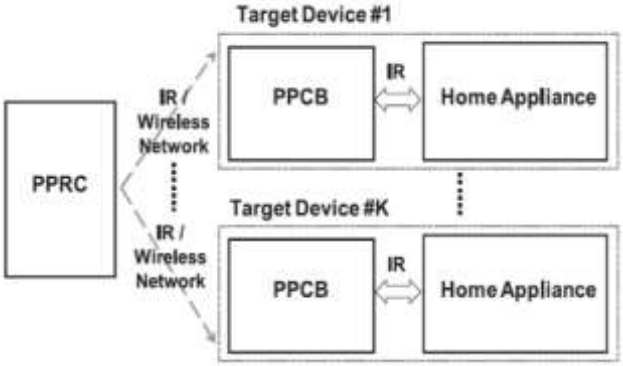

Figure. 2. System architecture of the proposed control system.

2.Primary Workflows

With the G sensor in the PPRC, the system can detect that the PPRC has been shaken (i.e., preparing to perform some control operations) and may be used for controlling appliances. The PPRC then sends a "Be Ready" signal to the PPCB in the vicinity via a Bluetooth or Wi-Fi wireless network. When a PPCB receives the "Be Ready" signal, the PPCB initializes and enables its internal IR receiver.

Once the PPRC is fixed on and pointed to a specific PPCB, the IR receiver of the PPCB subsequently receives the signal that was transmitted from the IR transmitter of the PPRC using directionality of the IR characteristic. During this time, the Target Control component of the PPCB simultaneously transmits the DCP to the URC Control component of the PPRC via a Bluetooth or Wi-Fi wireless network. After registering the received DCP to the Device Profile Registry component, the URC Control component generates a control UI via the Interface Generator component according to the DCP and state dependencies of the FSM. At this point, the PPRC can issue control commands using the corresponding control UI via the UPnP Control Point component.

The PPRC then transmits control commands to the UPnP Device component of the PPCB to control the specific target device. Last, the PPCB transmits the received control commands from the PPRC to the appliance to generate the corresponding control operations via an IR transmitter. The home appliance performs the corresponding operations issued by the PPRC.

IV. SYSTEM IMPLEMENTATION

To verify the feasibility of the proposed Point-n-Press control system, real prototypes are implemented, including a fan shows the operational UIs of real prototypes.

A. Demonstration With Real Prototypes

Control prototypes have been launched in IoT-based smart homes. The prototype is a fan, as shown in Fig. 1. The PPRC is implemented on the platform of a commercial smart phone, which is equipped with 1.2GHz, 1Gbytes random access memory (RAM), 16 Gbytes read only memory (ROM), a

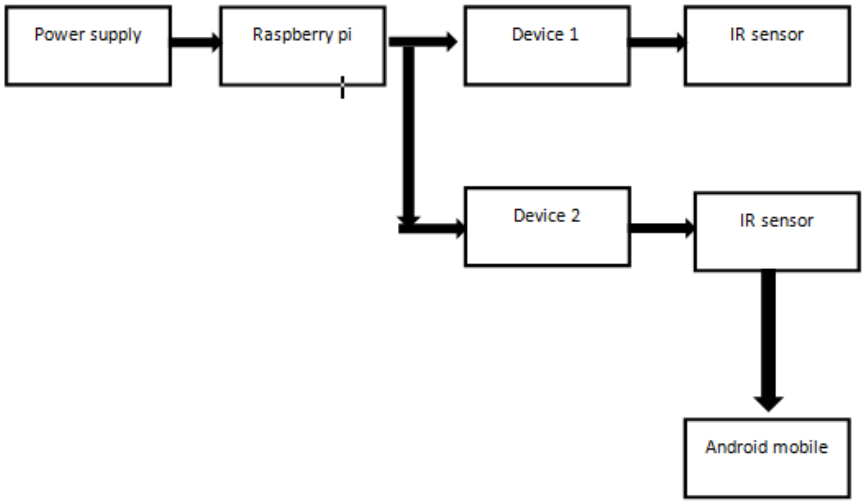

Figure. 3 Overall Block diagram of Point-n-Press: A shrewdly widespread remote Control framework to home Appliances

Bluetooth communication, a Wi-Fi communication, a G sensor, and a micro-universal serial bus (micro-USB) interface. In addition, all software components (e.g., UPnP Control Point and URC Control) are developed based on the Android 4.1 version. Fig 3. Shows the overall block diagram, the IR capability of the PPRC is provided by a USB IR transceiver dongle through a physical connection cable that is connected to the micro-USB interface.

Fig.4 shows the PPCB is employed with an ARM9-based development board, which is equipped with 200 MHz, 1 Mbytes Flash, 64 Mbytes Not AND (NAND) Flash, 64 Mbytes (synchronous dynamic random access memory (SDRAM), and 22 general purpose input/output (GPIO) interfaces. The internal software components are developed based on the Linux 2.4.18 version. The IR mechanism of the PPCB is designed with a narrow coverage range to prevent unexpected control operations of receiving multiple IR signals. The small and narrow hole is constructed and treated as the IR mechanism in the PPCB. Based on the design of this mechanism, the proposed control system can guarantee that only one device can be simultaneously pointed and controlled. Consequently, the proposed system always displays one control UI of a single appliance on the screen of the PPRC.

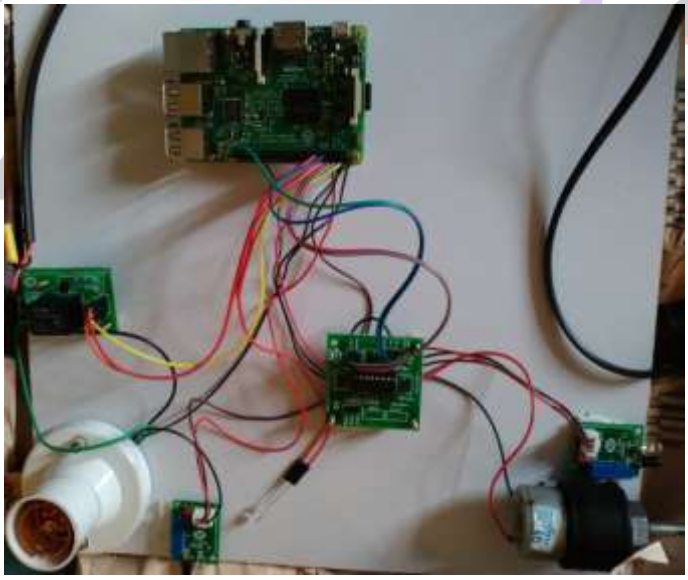

Figure. 4 Overall circuit connection of point-n-press

B. System Operations and UIsDemonstration

The operational UIs for controlling a fan. A smart phone, which is treated as the PPRC, is picked up, and the “Be Ready” signal is sent to the PPCB. No other control icons are displayed on the screen of the PPRC at this time. Next, the PPRC receives the DCP from the PPCB via a Bluetooth or Wi-Fi wireless network after the PPRC is pointed to the PPCB of the fan. The icon and the current state of the fan are displayed on the control screen (at this point, only the “Power” icon is displayed, which indicates that the fan is powered off, and other operations of the fan are not allowed). Fig.5 shows as the “Power” button is pressed, the state displayed on the screen of the PPRC is switched to power on. The fan is operated in normal mode with a moderate windspeed. After the “Mode” button is pressed, the fan is operated in natural mode without windspeed control functions (i.e., the “Speed” icon and related options are hidden).

Figure. 5 PPRC for Fan Point-n-Press: An shrewdly widespread remote Control framework to home Appliances

V. CONCLUSION

An intuitive control system with a set of user-friendly operations, called Point-n-Press, is proposed for controlling connected devices/appliances in IoT-based smart homes. The proposed scheme leverages the directionality characteristic of IR to enable easy and intuitive control of devices (i.e., controlling an appliance in smart homes by pointing to it). A user-friendly UI is designed by considering the state dependencies between each control operation. This design disables buttons that are irrelevant to the current context to prevent users from performing mal-operations. With the demonstration of two real prototypes with controlling appliances in smart homes, the feasibility of an intelligent universal remote control system for home appliances with intuitive and user-friendly features is verified. Consequently, the proposed Point-n-Press control system not only enhances the features of intuition and user-friendliness but also establishes a less bandwidth-consumptive control system. Nevertheless, the implementation of the proposed control system is currently limited to IR sensors. Moreover, state dependencies of devices/appliances must be manually identified. Therefore, to control devices/appliances with a more precise pointing mechanism, and to support an auto discovery mechanism of state dependencies are two possible directions for future research.

References

[1] F.Wang,L.Hu,J.Zhou,andK.Zhao,"A survey from the perspective of evolutionary process in the Internet of Things," Int.J.Distrib.Sens. Netw., vol. 2015, no. 9, pp. 1–9, Jan. 2015.

[2] M.Javieretal.,"From the internet of things to the internet of people," IEEE Int.Comput.,vol.19,no.2,pp.40–47,Mar.2015.

[3] L.Zhang,L.Zheng,H.Yang,andT.J.Pan,"Research of the key technologies of the smart home based on IOT," Appl. Mech. Mater., vol. 713–715, pp. 2304–2307, Jan. 2015.

[4]M.R.Alam,M.B. I. Reaz, and M. A. M. Ali, "A review of smarthomespast,present,andfuture,"IEEETrans.Syst.,Man,Cyber.,vol. 42, no. 6, pp. 1190–1203, Nov. 2012.

[5] K. Ben, P. Sachin, A. Pieter, and G. Ken, "A survey of research on cloud robotics and automation," IEEE Trans. Autom. Sci. Eng., vol. 12, no. 2, pp. 398–409, Apr. 2015.

[6] C.-H. Lu et al., "Energy-responsive aggregate context for energy saving in a multi-resident environment," IEEE Trans. Autom. Sci. Eng., vol. 11, no. 3, pp. 715–729, Jul. 2014.

[7] H.C.Tadimeti and M.Pulipati,"Overview of automation systems and home appliances control using PC and microcontroller," Int. J. Sci. Res., vol. 2, no. 4, pp. 127–131, Apr. 2013.

[8] T.Kim,H.Lee,and Y.Chung,"Advanced universal remote controller for home automation and security,"IEEE Trans. Consumer Electron., vol. 56, no. 4, pp. 2537–2542, Nov. 2010.

[9] J. Han, H. Lee, and K.-R. Park, "Remote-controllable and energy-saving room architecture based on ZigBee communication," IEEE Trans. Consumer Electron., vol. 55, no. 1, pp. 264–268, Feb. 2009.

[10]K.Gill,S.-H.Yang,F.Yao,andX. Lu, "A ZigBee-based homeautomationsystem,"IEEETrans.ConsumerElectron.,vol.55,no.2,pp. 422–430, May 2009.

[11] H. Erdem and A. Uner, "A multi-channel remote controller for home and office appliances," IEEE Trans. Consumer Electron., vol. 55, no. 4, pp. 2184–2189, Nov. 2009.

[12] M. Tezuka, Y. Honda, and M. Kato, "Development of bi-directional remote controller protocol and systems for domestic appliances,"IEEETrans.ConsumerElectron.,vol.46,no.3,pp.802811,Aug.2000.

[13] P.Palanisamy,"A universal device controller(UDC),"Int.J.Comput. Appl., vol. 82, no. 10, pp. 24–29, Nov. 2013.

[14] C.-F. Lai, M. Chen, M. Qiu, A. V. Vasilakos, and J. H. Park, "A RF4CE-based remote controller with interactive graphical user interface applied to home automation system," ACM Trans. Embed. Comput. Syst.,vol.12,no.2,pp.1–19,Feb.2013.

[15] W.-P.Sung,C.-M.Kao,andR.Chen,"Research and design of touchscreen domestic universal remote controller with self-learning function,"Appl.Mech.Mater.,vol.599–611,pp.1028–1031,Aug.2014.

[16] Y.-Y. FanJiang and T.-F. Chueh, "Adaptive user interface for universal remote controller," Int. J. Comput. Sci. Eng., vol. 10, no. 1–2, pp. 90–97, Feb. 2015.

[17] M. S. Alamgir, S. M. A. Z. Chowdhury, and K. T. Ahmmed, "Development of a PoE switch based remote control system for controlling home and office appliances with data communication facility," Int. J. ControlAutom.,vol.8,no.1,pp.103–110,Jan.2015.

[18] Y.-H. Sheng, W.-W. Lin, C.-S. Tu, and K.-M. Lee, "Integrate LonWorks and UPnP devices by OSGi gateway and universal remote console," in Proc. 8th Int. Conf. Adv. Commun. Technol., Phoenix Park, Korea, Feb. 2006, pp. 1848–1850.

[19] G.-J.Horng,C.-K.Lin,C.-H.Tseng,C.-H.Wang, and J.-F.Yang,"An agent-based smart home system and its service-scheduling mechanism: Design and implementation," Wireless Pers. Commun., vol. 78, no. 1, pp. 521–542, Sep. 2014.

[20] S.Pradeep and V.Padmajothi,"Brain controlled smart home network based on cognitive state," Int. J. Emerg. Tech. Comput. Sci. Electron. (IJETCSE), vol. 13, no. 2, pp. 59–62, Mar. 2015.

[21] P. Kabilan, H. N. Askar, P. N. Anand, S. Manimaran, and G. Venkatesh, "Facebook based home appliances security control and monitoring using microcontroller,"AsiaPac.J.Res.,vol.1,no.XXV, pp. 19–25, Mar. 2015.

[22] M. Miyakawa, Y. Maeda, and N. Koyama, "Relationships between usability and number of buttons of a universal remote console -preliminary experimental result-," in Proc. IEEE Int. Conf. Syst. , Man Cybner., Singapore, Oct. 2008, pp. 424–428.

[23]J.Haines and J.M.Winters, "Evaluating automatically generated personalized interfaces on an ergometer for people with diverseabilities," inProc.IEEEInt.Conf.Eng.Med.Biol.Soc.,Vancouver, BC,Canada, Aug. 2008, pp. 5632–5635.

[24] J. H. Andrews and F. Hussain, "Johar: A framework for developing accessible applications," in Proc. 11th Internat. ACM SIGACCESS Conf. on Computers and Accessibility, Pittsburgh, USA, Oct. 2009, pp. 243–244.

[25] H.Y.Tung,K.F.Tsang, H.C.Tung,K.T.Chui, and H.R.Chi,"The design of dual radio ZigBee home care gateway for remote patient monitoring,"IEEE Trans. Consumer Electron.,vol.59,no.4,pp.756–764, Nov. 2013. [26] C. I. Penaloza, Y. Mae, F. F. Cuellar, M. Kojima, and T. Arai, "Brain machine interface system automation considering user preferences and error perception feedback,"IEEETrans.Autom.Sci.Eng.,vol.11,no. 4, pp. 1275–1281, Oct. 2014.

[27] K. Lee, Y. S. Kim, Y. Wang, S. Kim, and K.-H. Baek, "A remote pointing device by using modulated IRsignals with a2-D striped pattern," IEEE Trans. Consumer Electron., vol. 59, no. 3, pp. 699–704, Aug. 2013.

[28] F. Portet, M. Vacher, C. Golanski, C. Roux, and B. Meillon, "Design and evaluation of as mart home voice interface for the elderly:Acceptability and objection aspects," Pers. Ubiquit. Comput., vol. 17, no. 1, pp. 127–144, Jan. 2013.

[29] R. Aoki, A. Maeda, T. Watanabe, M. Kobayashi, and M. Abe, "Twist&tap: Text entry for TV remotes using easy-to-learn wrist motion and key operation, "IEEETrans. ConsumerElectron.,vol.56, no. 1, pp. 161–168, Feb. 2010.