Remote Control Model for Smart Living–A Mobile Technology Approach

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Abstract: Smart Living or intelligent environment for living provides great comfort to the people. Smart Home is the concept of living in a home that is self-manageable, automated and user centric. Smart Living concept integrates assistance and comfort for disabled and elder person. Assistive/Adaptive Technology enhances the quality of life for disabled persons as it aims to reduce the effects of impairments. Disabled and elder person can perform daily life activities and participate in social life by adopting appropriate Assistive Technology device. Researchers as well as many industries view disability with different aspects and proposed smart devices to support disabled and elder person. Many appliances and comprehensive assisted living system are commercially available in market. These devices and systems are aimed to provide support in different walks of life but their integration on a single platform is major issue. Smartphone based Remote Control application with single interface could significantly assist living. In this paper, research group explore the high-tech assistive technology devices, which are either commercially available or proposed in research papers and categorize them according to their role in daily living. Further, research group propose a remote control model provided on mobile, which integrate assistive living functions and exploit mobile technology for smart living.

Keywords: Assistive Technology Device, Smart Living, Assistive Technology Categorization, Universal Remote Control

1. INTRODUCTION

Disability affects the routine life activities of disabled persons and leads them towards less quality of life. The disability may be mild, in which disabled person has adjusted with impairment and still able to perform routine life activities. In mild disability, disabled persons do not need human assistance and effects of disability/impairment can be overcome with assistance through devices. In case of severe disability the ability of disabled persons to perform routine life activities badly affected and disabled person need assistance. The adoption of appropriate assistive technology devices plays a vital role by enhancing the physical and learning capabilities of disabled person in different walks of life. Integration of small form factor computer chips, with many sensing and wirelessly connecting features, makes assistive technology devices context aware, automated, responsive and having ability of communicate with peer and central controlling system. Advance features of Artificial Intelligence and Computer Visions algorithms and Ubiquitous Computing make assistive technology devices more usable and internet accessible (Briggs and Little, 2009). The ability of automated speech recognition, face detection and gesture recognition are example of human computer interaction in more natural ways.

Most of advance home appliances have embedded computer in them and they are featured with connecting to home network and internet. These smart home appliances are capable of communicating with home server and through internet a centralized server. The concept of Internet of Things (IoT) emerged as a new way of computation with always connected and seamless computing environment. Remote control has become the common feature of today's home appliances. The design of remote control is specific to the appliance's functions and one appliance's remote control could not work with other appliance. For example, remote control for Air Conditioners could not work with TV, Home Theater. Hence, having at least 2 to 10 remote controls in a home is common reality for today's living. The management of such number of remote controls becomes cumbersome task for dwellers. The concept of Universal Remote Control was introduced to cope up the problem of having different remote controls for each device.

In order to make compatible with each appliance, there are many different controlling buttons, which make Universal Remote Control interface more complex and creates confusion. The world is trending toward widespread acceptance of Smartphone in their

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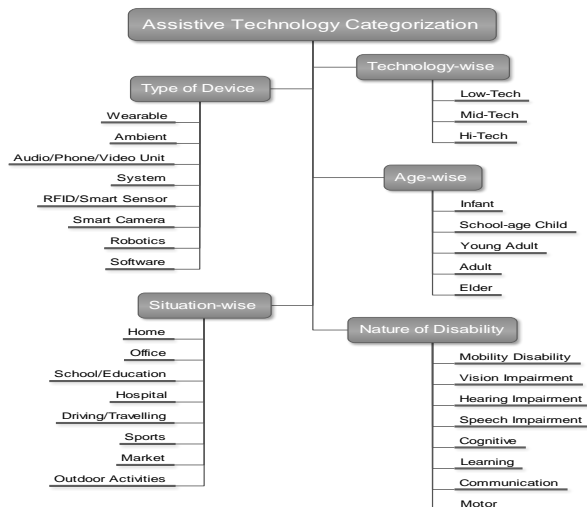
Fig.1. Assistive Technology Categorization

lifestyle due to embedded features offered in these handheld devices. Technological advancement in electronics and miniaturization in MEMS (Micro-Electro-Mechanical-System) make it possible that smartphone and other handheld devices equipped with high processing power, more memory and other high quality sensors. These devices are generally having a trend of always connected to the internet through 4G, 3G, Wi-Fi network. These features of smartphone and other handheld devices make it possible to create an environment of ubiquitous computing (Polastre, 2007). Due to inherited limitation of smartphone, interaction with these devices through traditional ways is difficult, due to which other more natural interaction ways are adopted in this type of computing. Touch, Speech, gesture and gaze recognition are new interaction methods in today's mobile computing environment.

Universal Remote Control Apps available onto mobile have addressed the problem of complex interface of hardware based Universal Remote Control. Many Remote Control apps available for Smartphone either free or on cost. In Universal Remote Control App, the appliance specific remote control interface is displayed when users selects a specific device from menu. In this work, research group presents a model of Voice based Universal Remote Control application. The proposed application will have the feature of auto-detection of nearby appliances/devices and works independently of any hardware patch. Rest of the paper is organized as follows: discussion and categorization of assistive technology devices given in section II while smart-home concept and its associated benefits are discussed in section III, the detail of proposed universal control model is given in section IV, and section V describes our proposed Voice based Universal Remote Control model and in last section we conclude our work.

2.   ASSISTIVE TECHNOLOGY

Disabled persons need assistance to accommodate their activities of daily living. Severe kind of disability limits their functional and/or mental capabilities. Without suitable human/devices assistance, they are unable to perform their routine activities and tasks. These tasks are necessary to maintain quality of life, and one's inability in doing these tasks can compromise quality of living. Assistive technology devices greatly reduce the burden of assistance from human and enhance their functional and mental capabilities. Without adoption of suitable assistive technology, disabled persons could not participate in various walks of life (Wong *et al.,* 2016) thus become a burden over economy. Assistive technology devices can be categorized in different ways. A basic categorization is according the technology i.e. low level technology, medium level technology and high level technology (Stokes, 2012). Assistive technology categorization is given in Fig. 1. Assistive technology does not aim to cure to disability rather it increase physical and cognitive capability of disabled/elder persons. According to WHO report (world report on disability, WHO, 2011), provisioning of appropriately designed assistive technology according to the need of disabled person and environment, resulting in reduction of cost of caring. Usually high tech devices are considered, not all but some of them, as context aware devices. There are different assisted living systems which are context aware such as CogKnow (Mulvenna *et al.,* 2007) an assisted system for elderly people suffered with mild dementia.

3.   SMART HOME CONCEPT

The concept of smart-home is based on automation of different functions while keeping the concerns of comfort, security and safety of dwellers. Current era of technology witnessed of small form factor of computer chips and sensors which are capable of perform different sensing and communicating. These tiny chips and sensors are integrated in different devices to make them capable of providing information and controlling their function remotely.

Speech Recognition:

Speech recognition is a process in which human spoken words are converted into text with the help of some specialized hardware and software tools (Li *et al.,* 2013). Ideally speech recognition should be independent of the environment, speaker or the device. In NSR (network speech recognition) system the client device collects and sends speech data to the server. Server converts speech data into text and return the result to the client. In DSR (distributed speech recognition) the client itself extracts, encodes, and transmits speech data through a shared network and data

link, and then server decodes the data. In DSR the process is distributed among client and server. In embedded speech recognition system the whole process of speech recognition takes place on the target device and no network connection is required (Garcia *et al.,* 2014).

ASR Problems in Mobile Devices:

Both type of hardware and software challenges make the speech recognition a complex task on mobile devices. ASR (automated speech recognition) needs to maintain a large database of words which are expected to be recognized, keeping this data on mobile device is difficult to manage due to limited storage space (Khalil *et al.,* 2012). Data compression requirement of speech recognition systems is also a hurdle in speech recognition (McGraw *et al.,* 2016).

Complexity: Assistive technology devices as well as home automation greatly enhance the quality of life for disabled person by providing assistance in different walks of life. Remote control is also a part of assistive living where it provides features to control the functions of device remotely. However; the dark side of the story is that high tech devices and appliance have their own remote controlling unit, complex interface of remote control pose a cognitive load on disabled person and smart home devices follow their respective standards and do not allow devices with other standard to integrate in system. There are numerous Remote Control Apps available which provide single platform to control different devices through smart phone but these apps have a menu to select to respective device to display device specific remote control interface. This situation can pose difficulties for disabled person.

4.   UNIVERSAL REMOTE CONTROL

Despite greater contribution of remote control in smart living, there are issues associated with remote control. Disabled person and elder person face difficulties due to interface complexity of the remote control. A substantial problem that people face is managing a pile of remote control in different rooms of home. This problem was addressed from researcher and industry by introducing Universal Remote Control unit.

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Hardware Based Universal Remote Control

The idea of Universal Remote Control is date back to 1985 by Philips (Rumbolt and McIntyre Jr., 1988) and many Universal Remote Control such as in (Universal Remote Control, n.d.) are commonly available. In order to be compatible with different types of appliances, Universal Remote Control has many buttons with different functions. Some of the buttons are specific for one device and has no use for others thus make the Universal Remote Control interface complex. The complex interface reduces the usability of Universal Remote Control and creates cumbersome situations for user.

Universal Remote Control Application available onto mobile

The complex interface issue of Universal Remote Control is addressed by introducing Universal Remote Control Apps available on Smartphone. Appliances are still use infrared beam as controlling medium and Smartphone do not have infrared emitter built-in, therefore; mostly the provider of Universal Remote Control App supply infrared dongle.

Table-1 Comparison Of Features Of Differetnt Universal Remote Control Application

Remote Control Device & Applications	InfrRed Dongle/ Encoding	Auto-Device Selection Feature	Wireless Medium (Bluetooth/ Wi-Fi)	One Interface for different devices	Flexibility for Design own interface	Auto-Scheduling/ Pre-Scheduling
X10 Commander (X10 Commander, 2012)	✘	✘	Wi-Fi	✘	✘	✘
iRule(iRule, 2012)	✔	✘	Wi-Fi	✘	✘	✔
AT&T Universal Remote Control	✘	✘	✘	✘	✘	✘
SURC (SURC, 2012)	✔	✘	✘	✘	✘	✔
Beacon (Beacon, 2012)	✘	✘	Bluetooth	✘	✘	✘
Contol4® (Control4, 2012)	✘	✘	Wi-Fi	✘	✘	✘
L5 Remote (L5 Remote, 2012)	✔	✘	✘	✘	✔	✘
Logitech Harmony (Logitech Harmony® 1100, 2012)	✔	✘	✘	✔	✘	✘
Universal Remote Control	✔	✘	✘	✘	✘	✘
SixthSense (Anthony, 2012)	✘	✘	Wi-Fi	✘	✘	✘
Voice based Universal Remote Control model (Proposed in this paper)	✘	✘	Wi-Fi	* ✔	✔	✔
		*Automatic *On demand	Automated Sensing & Interoperability	* multiple interface swapping by single button	Pre-designed interface	Pre-scheduling the devices and set them as while in range

The dongle is attached with smartphone and is responsible for converting controlling signal to infrared so that respective appliance can be control.

Some Apps are using IR blaster to convey controlling signal to device. A comparison of Universal Remote Control is given in Table-1.

Universal Remote Control Apps has remarkable contribution in smart living. It not only offer a true Universal Remote Control in your Smartphone that can work with thousands of appliance but also offer different features such as fine interfaces of remote control, personalized design feature, large database of remote control codes for available devices, adaptation of new code for newly introduced appliance. However;

despite greater usability of Universal Remote Control Apps, there are still some problems like attaching dongle, selecting particular device from menu, and using common controlling feature of different device by different remote control interface .

6. VOICE BASED UNIVERSIAL REMOTE CONTROL MODEL

In this section, the proposed Voice based Universal Remote Control Model is elaborated. The model is comprehensive enough in respect of problems discussed previously which make this model a significant solution to reduce the complexity face by disabled and elder persons.
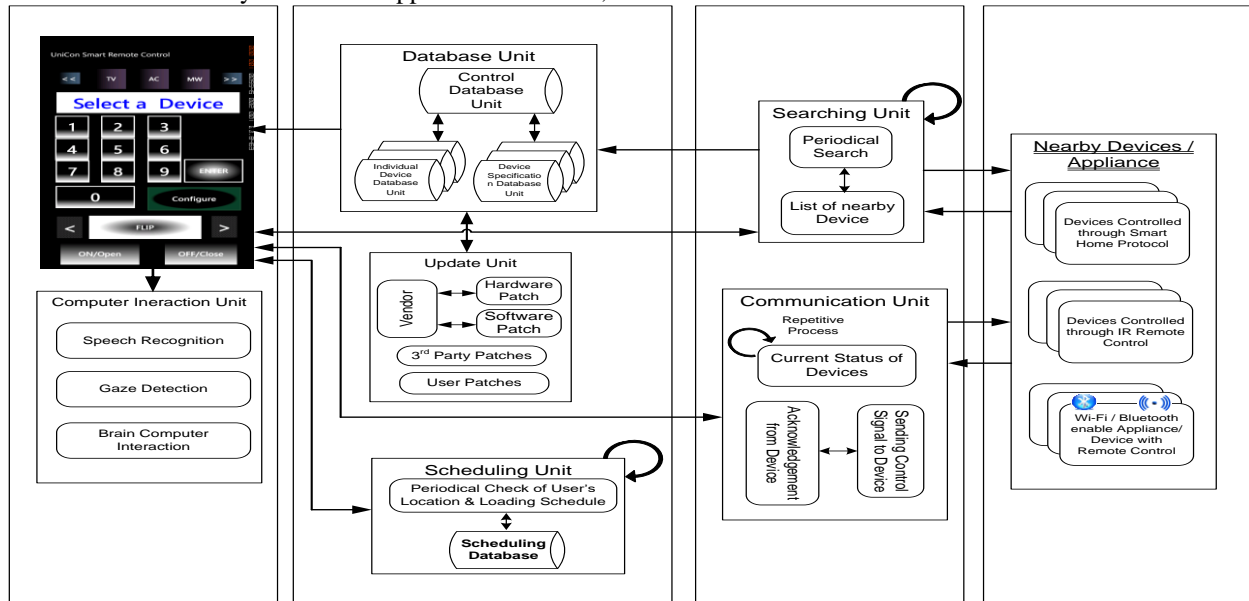

Fig.2 Voice based Universal Remote Control Model

The Voice based Universal Remote Control model is shown in Figure 2. It has a modular architecture and has four modules, and one application. Each module is further divided in different units responsible to their given task. For this model, this research proposed design consideration for application, which is given in following sections. In this model, appliance and devices are grouped in categories as (a) Wi-Fi/Bluetooth enabled; (b) InfraRed based; and (c) device follows Smart Home protocols.

Most of appliance and device marketed with remote control with InfraRed as medium for convey the command to device. InfraRed has limitations of line of sight, working only in close proximity. Keeping in consideration the limitation of InfraRed, this research proposed/assumed that Appliances/devices are Wi-Fi / Bluetooth enabled , have their unique ID, context-aware and able to broadcast their current operational status. This research proposed that a software and/or hardware

patch is provided by Vendor or third party provider for those devices which do not fulfilling above mentioned criteria, so that these appliances can meet the Voice based Universal Remote Control Model requirement.

Integrated Universal Remote Control Application

From reviewing several Universal Remote Control applications, assistive technology devices and smart home feature participation in assistive living, this research proposed a Universal Remote Control model, which is capable of following features:

- Automatically detects all nearby devices
- Single, simple and easy to understand interface
- Interface self-designing feature
- Updates the nearby device list based on user location
- Single button to load respective device original remote control interface for advance features
- Flexible to adopt new standards

Voice based Universal Remote Control Model Description

Voice based Universal Remote Control model, as depicted in **(Fig. 2),** is divided into six units described below.

Database Unit

Controlling codes database is most important unit of any Universal Remote Control application. Controlling codes of devices and appliance different from each other, hence in this way it is possible that we could operate different devices with their respective remote control. Universal Remote Control applications designed to control different devices with their functionality, these Apps require a large database of controlling codes for a range of available devices and appliances. Database unit is responsible to storing, managing and updating the general controlling codes of devices that are currently available as well as devices that will be approached in future. Sub-units of database unit are Control Database Unit, Individual Device Database Unit, and Device Specification Database Unit.

Control Database Unit

This unit is responsible for loading control codes of all in-ranged devices. As per design perspective of simplicity, only general/common codes will load in memory. The general/common codes are device specific common controls that are most commonly used. This feature helps in less memory utilization of Smartphone or handheld devices.

Individual Device Database Unit

This unit is responsible of device specific advance controls and their respective interfaces. This unit loads devices specific advance control and interface when user wants to use advance controlling functions of device. This functionality can be performed by pressing a FLIP button.

Device Specific Database Unit

This unit is a library of devices/appliances specification common controlling codes and advance controlling codes with device specific interface. This unit serves the request comes from Control Database Unit for common codes and Individual Device Database Unit for original interface and advance control codes.

Computer Interaction Unit

Computer Interaction Unit is an equally important unit in Voice based Universal Remote Control model. It responsible for provisioning support for special interaction techniques such as Speech, Gesture or Gaze. This unit is very helpful for disabled and elder person and provide natural ways of interaction with home appliances through the use of Smartphone.

Searching Unit

Searching unit is responsible for periodically searching the nearby devices/appliances, updates the current in-range device list and sends this information to Database Unit so that control codes can be loaded.

Searching is based upon device's broadcasting feature in which they show their status and location.

Communication Unit

Communication Unit is responsible for getting current status of all in-ranged devices/appliances such ON/OFF, operating level and keep update the proposed Voice based Universal Remote Control application device information. This unit is also responsible for sending controlling signal to devices/appliances and getting acknowledgement from them.

Scheduling Unit

Scheduling unit is responsible for detecting the user's current location and sets the surrounding devices to a predefined state. Scheduling unit is important feature of Voice based Universal Remote Control model and enhances the smart living lifestyle. This unit is further sub-divided into location-based unit and scheduling unit.

Location-based Unit

Location-based unit is responsible for detecting the user's current location, using some location-based services (Junglas & Richard, 2008). This feature is helpful for low-energy producing county and for those families, which intended to reduce their energy consumption.

Scheduling Database Unit

Scheduling database unit is responsible for maintain user's specific requirement of pre-defined status of devices/appliances at different location of home.

Update Unit

Update module is responsible for updating the database unit. As new devices/appliances are continuously approaching, their controlling codes and specific interface must be added. Further, if a manufacturer updates its device features or functionalities, this unit also update. In case of any device does not fulfill Voice based Universal Remote Control model requirement, such as lacking Wi-Fi/Bluetooth functionality, a hardware patch is proposed to be attached to make them compatible with Voice based Universal Remote Control model. Hardware patch can be provided either by device manufacturer or can be adapted by 3rd party developers.

7. **CONCLUSION**

In this research, assistive technology is discussed in different aspects such as categorization and classification; it impacts over disabled and elder person in enhancing quality of life and technological advancement in high tech assistive technology devices.

This research also investigates the impact of smart-home in life of disabled and elder person. Various aspects of Remote Control are discussed and a comparison is provided in Table 1 which shows

different Universal Remote Control and their pros & cons. A new concept of Voice based Universal Remote Control model is presented. In this paper, research group proposed an idea of voice based Universal Remote Control model on Smartphone. The feature of auto-detection of devices in user's proximity and controlling devices through Bluetooth/Wi-Fi is introduced. The scheduling feature is also proposed with controlling the devices in pre-defined settings. The scheduling feature will be very helpful for disabled and elder persons and assist them in easily moving from one location to other without worrying about turning ON / OFF the devices. The research group, in future, will enhance application controlling features, propose standards for appliances/devices to be compatible with Universal Remote Control application.

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