



## Review Paper

# UniCon Remote Control Model – A Mobile System for Assistive Technology

Ahsan K., Iqbal S., Nadeem A. and Sarim M.

Department of Computer Science, Federal Urdu University of Arts, Science and Technology, Karachi, PAKISTAN

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## Abstract

People with disability of any kind i.e. physical, mental or psychological may still be able to actively participate in society and spend a better life by using Assistive Technology devices/appliances. Assistive technology refers to the technology that provides assistance to disable person in reducing the effects of disability and enabling them to take actively part in their routine life. Researchers have proposed different AT devices as well as comprehensive systems to help people with disability in various areas. There are many industries, which intensively focused on designing and implementing AT devices or systems for disable persons, but integration of these devices and systems from different vendors is a major issue. Elder people or people with health issues use a significant number of AT devices/appliances on day-to-day basis. Operating these appliances with single mobile remote control can assist their living. However, as various vendors provide these appliances, compatibility of these appliances with single interface is challenging task. Mostly these devices/appliances and systems are not compatible with each other. This research proposes a model for universal remote control provided on mobile. This model integrates assistive living function and exploits mobile technology for providing a consistent interface for handling every device/appliance. A familiar interface for every device/appliance can assist people specially elder/disabled person to handle various devices and provide good user experience.

**Keywords:** Disability, assistive technology device, smart home, mobile technology, universal remote control.

## Introduction

Disability, by definition, is a state of a person which is significantly impaired to the state of an able-bodied person, affecting the ability to perform normal life activities<sup>1</sup>. If someone feels difficult to perform normal life activities such as sighting, hearing, talking, walking, climbing stairs, lifting or carrying objects, learning in schools or understanding job at work place and assisted by someone (caregiver) or something (assistive device), the person considered to be as disabled. The disability may vary from early stages which do not much bother the person in spending normal life such as weak eyesight, slight lameness etc. to a stage where the disable person could not spent an independent life and must need assistance either through a caregiver or through Assistive Technology devices. Provisioning of better health services and enhanced quality of life in western countries imposed an impact of rising trend over population above the age of 65<sup>2</sup>. Disabled persons or elderly persons have a need of providing care at their living places such as home, nursing homes and hospitals. Japan is also facing the problem of increase in aging population and researches are conducted to explore the cause of increase in aging population, the challenges and propose solution for it<sup>3</sup>. Providing care to these persons has imposed a burden not only over their families but also over the available manpower, public resource and on the overall economy<sup>4</sup>.

The technological advancement in the field of electronics makes

it possible to produce sufficiently small, powerful and low cost computers on a small chip that could be integrated with items of daily living. These small chips, equipped with WLAN interface such as Wi-Fi or Bluetooth GPS based positioning system, special sensor for sensing different parameters of their environment that can be used for contextual information; make it possible to create an Ambient Intelligent environment<sup>5</sup>. The devices/appliances that are equipped with these small chips change the way of traditional computing to pervasive or ubiquitous computing, a way of computing in which people interact with embedded (and mostly invisible) computers. These networked devices are aware of their surroundings and are able to provide services or use services from peers effectively. Integration of these small computers in daily life items and especially in the Assistive Technology devices makes them so sophisticated that they can support in enhancing the quality of life of human. Assistive Technology devices are becoming more responsive that not only they are capable to support the disability of a person but also have the ability to communicate with each other and with central controlling system.

Advancement in technology in different fields i.e. wired and wireless networking, MEMS (micro-electromechanical system), mechanical and control engineering, smart sensors, reduced cost and higher availability of bandwidth and computers and their combination had brought the idea of smart homes to become true. The concept of smart home profoundly changed the way of living not only for the normal persons but also has a great

impact in providing support for spending independent life of disabled and elder persons. The concept of smart home has come true with the availability of smart objects and range of communication techniques that enable these objects to connect with each other and with central control system through wireless or wired medium<sup>6</sup>. Smart home provides several features including but not limited to comfort, security, safety, care, resource conservation, complete home automation, smart gardening and many more.

Many home appliances/devices such as air conditioner, TV, home theater etc. has feature of controlling their function using remote controlling device. The features of smart home can also be controlled through these remote controlling devices. However; each appliances/devices with their own remote controlling device as well as smart home systems with different standards having their unique function, creates an awkward situation for the dwellers to maintain a pile of remote control devices. With the realization of this situation, developers introduced a remote controlling device known as Universal Remote Control that can program and can be used to control almost every device/appliance.

Initially the intention of cell phone is to provide communication need on the go but with the increase in processing capability and availability of higher memory in Smartphone, they also fulfilling the computational needs of people on their palm. Many useful Apps are available for Smartphone working on different operating system such as iOS for Apple, Windows for Mobile, Google Android, etc. helping in performing routine tasks to normal population but also provide supports to handicapped in overcoming the consequences of disability. There are many Universal Remote Control applications available for Smartphone and tablet PC either commercially or free of cost. Most of these Universal Remote Controlling applications are not capable of detecting the nearby appliance and the intended appliance is required to be explicitly selected from menu. More to this, these applications require an additional hardware patch required to be attached with Smartphone called dongle that convert the signal generated by application to InfraRed signal so that appliance can be controlled.

## Disability

Disability, by definition, is a state in which a person is significantly impaired with the state of an able-bodied person. If someone feels difficulties in performing activities of daily living due to any kind of disability such as sighting, hearing, talking, walking, climbing stairs, lifting or carrying objects and assisted by caregiver or through assistive technology device, the person considered to be as disabled. Disability affects the ability of a person to perform normal life activities<sup>1</sup>.

The disability/ impairment may be physical, sensory, cognitive, intellectual, mental illness and many other chronic diseases.

**Type of Disability:** The impairment encounter by a person may be physical, sensory, cognitive, intellectual, mental illness and many other chronic diseases. A physical impairment includes congenital anomaly, cerebral palsy, amputations, and fractures may be either by born, caused by an accident and illness (polio etc.) or consequence of old age adult such as Alzheimer's disease and limits a person's ability to independent movement and performing basic life functions. Natural disasters such as earthquake, tsunami or volcanic activity heavily impacted the population of affected areas and one of the big causes of massive physical and cognitive disability<sup>7</sup>. A sensory impairment includes blindness, deafness, lack of balancing, inability of sensing touch and limits capability of disabled person. A cognitive impairment includes but not limited to Dyslexia, Attention Deficit Hyperactivity Disorder, Brain Injury, Genetic Disability Down syndrome, Traumatic Brain Injury (TBI), Autism, or Dementia Dyscalculia<sup>8</sup>. In review of depression, it is revealed that long term disability or illness is a developing cause of depression<sup>9</sup>.

**Disability Statistics:** It is estimated by WHO in their report on disability published in 2011 that around 15% of the world population (around one billion) is living with a minor or major disability<sup>10</sup>. USA economy has born a burden of 54 millions of disabled Americans that suffer from a physical or cognitive disability<sup>11,12</sup>.

**Effects on Caregiver:** Disabled people needs care-giving from others so that they could spend better life, however; Pruchno and Potashnik<sup>13</sup> express the consequences of care-giving on care-giver. In their study, they identified that the caregivers who provide care to disabled person with Alzheimer's or a related disorder, has more mental illness (such as depression) than non care-giver. The other consequences of care-giving are economic and other burdensome<sup>14</sup>.

**Disability Rights:** In USA, every person has equal rights despite characteristics such as disability, gender or race therefore disabled persons by Law can obtain equal opportunities in employment, schooling, entertainment, services etc.<sup>15</sup>. Landlords, employer, school as well as government is bound by law to provide special services to disabled persons so that they must fully functional in schooling, work place, residence or while entertaining in parks, cinemas or other entertainment places.

**Social Aspects of Disability:** Disabled persons have a trend of avoid using appropriate assistive devices specially in social gathering only due to social stigma that they were consider less capable despite the fact that assistive devices reduce the effects of disability and even they are fully capable and could perform their job to the level not less than to a normal person<sup>15</sup>.

## Smart Home

Advancement in technology in different fields i.e. wired and

wireless networking, MEMS (micro-electromechanical system), mechanical and control engineering, smart sensors, reduced cost and higher availability of bandwidth and computers and their combination had brought the idea of smart homes to become true. Smart home provides several features including but not limited to comfort, security, safety, care, resource conservation, complete home automation, smart gardening and many more. Not only providing comfort and control to an able-bodied person, smart home also provides support for persons with disability and old people to spend better quality of life thus living independently without need of care-giver. A smart caring system such as fall detection, wandering in sleep etc. provides caregiver an opportunity to keep an eye on his/her loved ones while going at work and/or live at distant place. Other smart surveillance systems provide the opportunity to community services provider/Police to remotely monitor specially those homes in which elderly persons/persons with disability live independently.

The idea of home automation came into existence dates back in 1970<sup>16</sup>. Controlling home appliances through remote control, automatic controlling of lighting based on day-light and based on presence/absence of person in any part of home, automatic environmental control on the basis of need of person that live in the home at particular time and sprinkle system for watering plants according the unique need of plants etc. are some common benefits of smart home.

Initially different devices and appliance such that TV, Stereo systems, air conditioners etc. were controlled through different remote control with their own standards introduced by their manufacturer. However; different devices with different standards and each device having their unique remote control create a situation for the residents to think about that either these devices providing easiness for the life or creating a cumbersome situation of maintaining the pile of these remote controls in every room. Up to some extent, the problem would be solved by introducing the multipurpose remote control which can control different devices but it is not a complete solution.

In order to address this problem and to take the complete advantages of smart home, complete home automation standards i.e. X-10, EnOcean, Z-Wave, UPB, INSTEON, KNX etc. were introduced which integrate different appliances, lighting system and other controlling system to work on a single platform so that the residents don't need to have different controlling devices to operate them. However; applying a specific standard to automate a home arises another problem that the user has to buy only those devices which are designed to work with the standard which is currently installed in the home. This restricts the user to buy only those devices which are designed for specific standards and if there is a particular need for which no device is available designed for such specific stand, user need to buy a complete system according to the other standard so that such device can work properly.

This problem had been addressed in a way that manufacturers produced different devices which are compatible with more than one standard so that these devices can be installed in smart home regardless of any standard. On the other way around, new standards have been proposed which are successors of the different standards and supports all previous devices which were designed to work with predecessor standards. Such an example of this is KNX which is successor of European Home Systems Protocol (EHS), BatiBUS, and the European Installation Bus (EIB or Instabus)<sup>17</sup>.

The advent of internet has opened up new opportunities to offer a person more control on smart homes while a person away from home. Using web service, a person not only can monitor and control his home devices from anywhere at any time but also takes care of his loved one lived behind home. Location Based Services and Cloud Computing are technologies that have significantly impacted our daily life in a positive way, also beneficial in controlling smart home features remotely<sup>18</sup>. In order to control the home remotely, home automation standards either have been updated and/or new modules were added or completely revised to take complete advantages of internet based home care and control. In recent past, this feature is accessible through desktop computers with internet connectivity however, the invention of Smartphone with internet connection changes the situation dramatically and one can now control his home devices while he was travelling or enjoying a picnic at beach.



**Figure-1**  
**Some Smart Phone application for controlling devices**

Keeping in view the increased use of Smartphone, developers came to the idea of controlling the devices through remote control application. In this regard, developers introduced different applications (Apps) for smart phones which integrate all the controlling functions of smart home in it<sup>19</sup>.

A home automation controlling Application has been developed that integrated the features of controlling all the devices working with different home standards and keeping in view the security, the information about device drivers and controlling features are placed on a server which is installed at home<sup>20</sup>.

**Smart Home Standards and Assistive Technology Devices:**  
A smart home not only enhances the quality of life but also provides care and support to persons with mobility disability, cognitive impairments or elder person.



Figure-2

**Main menu of application, scheduled management and top view of house**

Most of high tech assistive devices which are either commercially available in the market or proposed in research papers do not follow any of the smart home standards discussed above and have their own controlling standard.

Some high tech devices or systems are although available which are following smart home standard but they are marketed as a part of smart home and are not specifically addressing any kind of disability. These devices or systems are useful in addressing disability such as mobility impairment, cognitive impairment or help elder person and following their respective smart home standards or compatible with more than one standard such as INSTEON or KNX.

**Related Work**

Controlling different devices and appliance such as TV, VCR, Cable TV, Satellite TV, CD/LD, VCD/DVD and Hi-Fi through single universal remote control is not a new idea and few remote controls like Universal Remote Control are available commercially since long in the market<sup>21</sup>. These universal remote controls not only provide the solution to the problem of keeping a pile of remote controls in every room of home but also have a large database of available appliances to be added when a new appliance is purchased. As new devices are continuously introduced from manufacturers, either their controlling code provided by the manufacturers or by the company that provides universal remote control.

The idea of using smart phones as universal remote control comes along with the arrival of the smart phone and many applications for smart phones available from different providers such as Apple App Store, Google Play. As devices still use remote control that emits Infra Red beam and require a line-of-sight interaction to control them remotely and new smart phones does not have a built-in Infrared emitter therefore remote control application providers also provide some external device in the form of dongle that is require to be attached with smart phone. The dongle is required to convert the electrical signal into Infrared signal to control devices with Infrared remote control. Some application does not use a dongle instead they use a gateway that receive the controlling signal through Wi-Fi or Bluetooth and convert it into Infrared signal of a particular device to be controlled. However, new devices are now manufactured with provision of Wi-Fi / Bluetooth and ability to

connect with Wi-Fi network to make them more digitize and internet accessible.

**Comparison of Universal Remote Control Application available onto mobile:** During navigation and searching, very less assistive devices are found remotely controllable but there are plenty of appliances and many smart home devices, which are controlled through remote controls. An elder or impaired person (visually, hearing, cognitive, etc.) may face difficulty in operating different interfaces of remote control application for different appliances. One of the big problem which also substantial is that keeping a pile of remote controls together is also a cumbersome task. To avoid this problem a number of universal remote control devices and application are proposed. Following is the brief description of Universal Remote Control Apps.

The X10 Commander URC App is available for Apple iOS and Google Android platform which facilitates the user to control different devices using Smartphone<sup>22</sup>. iRule App turns Smartphone into a powerful touch screen universal remote control<sup>23</sup>. It can control audio/video equipment, lights, drapes, fireplaces, and many other home devices and appliances. SURC is an app which runs on any smart phone and can control IR appliances<sup>24</sup>. Control4 provides the feature of controlling home appliances and devices through the any computing platform such as mobile/Laptops, desktops and tablets<sup>25</sup>. Using Beacon app, user can control its home entertainment system (TV, DVD, Blue Ray, stereo system, etc.) through Smartphone<sup>26</sup>. L5 remote facilitates its user to create its own remote interface in its mobile<sup>27</sup>. Through plugging the accessory device in iPhone, iPad, or Tablets, one can make enable to learn the signals of any IR remote control buttons to iPhone, iPad, or Tablets. It allows creating very simple interfaces easy for one to use. Logitech Harmony® 1100 Advanced Universal Remote is a remote control which can control more than 225,000 devices<sup>28</sup>. It is an app for iPad, iPhone, or iPod touch which can turn Smartphone into remote control by attaching accessory into phone to control home theater components. SixthSense is an app which uses the Smartphone's camera and computer vision technique to work out what the person is pointing at and then can give signals through Wi-Fi to control that device<sup>29</sup>. Although they provide a very fine interface to use but most of them are difficult to operate as they are viewed from elder or impaired person.

**Integrated Universal Remote Control Application:** In spite of the greater usability of universal remote control applications, they pose a problem of complexity especially to disabled and elder persons. From the above mentioned review about Universal Remote Control Apps, it is clear that a user has to either select a particular device from a menu or Apps has shortcut of many devices for selection and after selection, device specific remote control interface will be appeared on the smart phone screen. Further to this, attaching an external dongle with smart phone to control those devices which are still working with Infrared signal is an obstacle for easy living for disabled / elder people.



Figure-3

**Universal Remote Control Applications available onto mobile**

Most of home appliances / devices after their installation/initialization have some common controlling functions to be used in routine life. The list of devices/appliances with most common controlling functions through remote control in table 1.

**Table – 1  
Common Controlling functions of device**

Name of Device	Common Controlling Functions		
	ON / OFF	Increase / Decrease	Switch / Toggle
TV	✓	✓	✓
Music Player	✓	✓	✓
HVAC	✓	✓	✓
Microwave Oven	✓	✓	✓
Stove	✓	✓	✓
Geyser	✓	✓	✓
Electric Kettle	✓	✓	✓
Draper	✓	✓	✓
Door/Window	✓	✓	✓
Lights	✓	✓	✓
Fan	✓	✓	✓
Wheel Chair	✓	✓	✓
Sprinkle System	✓	✓	✓

Keeping in view that remotely controllable devices/appliances have most common controlling features, this research proposed a universal remote control application for smart phones which has a common interface for every device in the premises of user.

**UniCon Model**

After reviewing different Universal Remote Control applications, we suggest that there is a strong need to present a model that overcomes to the complexity posed by these universal remote control applications such as connecting an IR dongle with mobile phone. We briefly describe about UniCon Model, which is comprehensive enough to overcome all the

problems posed by available remote control applications in previous section.

The UniCon model, as depicted in figure 4, consists of four modules and one group of appliances, which is further divided into three categories and one application. Three categories of group of appliances are i. Wi-Fi / Bluetooth enabled appliance, ii. IR controlled devices and iii. Devices controlled through Smart Home Protocol

IR is the most used communication medium between remote control device and appliance although it has limitations such as it requires a line of sight connection and cannot cross solid obstacle such as walls. Considering Infrared limitations, it is assumed/proposed that all new appliances must be capable of communicating through Wi-Fi / Bluetooth and UPnP, have their unique ID, context-aware and capable of broadcasting their current operational status.

For those appliances which are not fulfilling above mentioned criteria, it is proposed that software/hardware patch will be provided by Vendor/ 3rd Party Developer/User so that they could interact with our application.

**Design Consideration and Specification of Universal Remote Control Application:**

Design considerations and specifications for UniCon Universal Remote Control Application are: i. Application must automatically detect all nearby devices on the location of user. ii. Application must versatile enough to accommodate a significant set of appliance as the number of wireless standard and home automation products are expanding. iii. The interface must be flexible and upgradable. iv. Application should change the list of nearby devices / appliances when user changes his location. v. If a requirement to control the appliances / devices not fulfilled by UniCon, the device respective remote control should be displayed on screen by pressing FLIP button, vi. Application should has a feature to facilitate the user to create its own designed remote control.

**Description of Universal Remote Control application model:**

Universal remote control application consists of four modules and a set of appliances / devices required to be controlled. i. Driver Database Module, ii. Update Module, iii. Device Searching Module, iv. Communication Module.

**Driver Database Module:** It is the main module containing three of its sub modules and a library of drivers for most of the commercially available appliances / devices. If manufacture upgrades its device driver, the update will be automatically adopted by UniCon application. However; as new devices are continuously approaching, this driver database will be updated periodically as per requirement. Both of these requirements will be fulfilled by using Update Module.

**Control Database Module:** In this module, drivers for currently in-range devices will be loaded from Individual

**Device Specification Module.** The device list comes from Searching Module.

**Individual Device Specification Module:** This module is the library of drivers for most of the available devices and serve the request comes from the Control Database Module.

**Individual Device Remote Control Module:** User can use the FLIP button to view the original remote control of particular device if it does not satisfy with the interface provided.

**Update Module:** In case of unavailability of device driver in the Driver Database module the update module will provide update to it. Manufacturer, user or 3<sup>rd</sup> party developer will provide update for newly introduced devices.

**Device Searching Module:** The list of nearby devices/appliances is populated by this module on periodical basis according to the user's current location in its environment.

**Communication Module:** This module is responsible for exchanging status information among active devices.

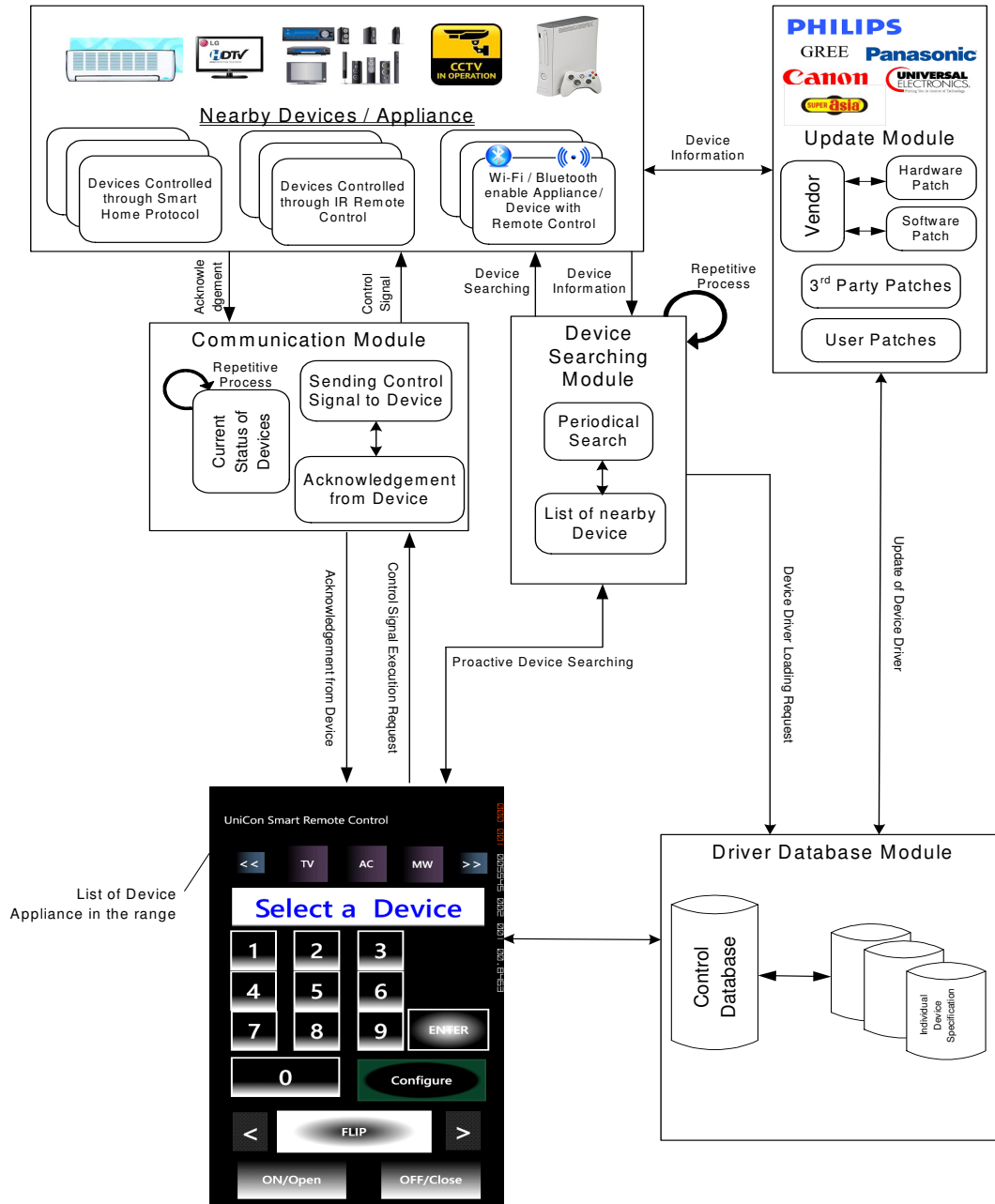


Figure-4  
 UniCon Model

**Usability Test:** A survey has been conducted to check the usefulness and necessity of the idea of Universal Remote Control Application for smart phone that assist people belong to different age groups, different academic background and technical expertise, disabled and normal person etc. The scope of the survey is to determine that how majority of people using smart phones thought about the usefulness of smart applications and to find out the impact of universal remote control application. Table 2 gives the demographic view of the participants.

All the participants are using at least one remote control device in their home or workplace and 33 out of 37 people feeling comfortable using remote control at their environment. As majority of participants is using smart phones, this survey shows that smart phones have become a common handheld tool that not only fulfilling their communication needs but fulfilling their computing needs also. The participants are much familiar with smart phone applications and would prefer that applications should have an easy interface for using. The survey was conducted in Karachi, Pakistan which is an underdeveloped country and technology has not reached to that extent than in developed countries. The majority of the participants is educated, belong to a developed environment and most of them have a technical background, however; for most of them the concept of universal remote control application is new and inspiring. When the idea was visualized to them, they feel comfortable about using application and a vast majority of participants (27 people) preferred single and easy interface of universal remote control in order to control most common features of different devices.

**Table-2**  
**Demographic View of Participants**

Gender	Male				Female				
	19								
Age-group	15-25		25-35		35-45		45-55		55-65 and above
	8		18		6		4		1
Education	Primary	Middle	Metric	Intermediate	Graduate	Masters	PhD		
	0	1	2	2	16	14	2		
Workplace	Education Institute		Shop		Factory		Office		Other
	23		0		0		12		2
Work Type	Outdoor Work			Indoor Work			Unemployed		
	6			26			5		

**Conclusion**

In this research, the disability in different context and assistive technology devices in a generalized way are highlighted. This research also investigates the smart home standards and improvement and enhancement obtained by smart homes in quality of life of normal and disabled persons. A comparison between different universal remote control applications currently available in market for remotely controllable devices/appliances as well as smart homes have been given in this paper. This paper provides the idea of Universal Remote

Control application for smart phones with a new feature of automatic detection of nearby device and controlling different devices through Wi-Fi or Bluetooth. In the future, we will try to enhance application features, controlling standards for appliances/devices and prepare a patch for compatibility with devices.

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