Augmented Reality Control Home Appliances Using Smart Phone

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Abstract: - *In this project, we will describe how we implemented augmented reality ,voice control & web server to control these home electrical appliances for elderlies and disabled. We will develop a Home Automation system that employs the integration of multi-touch mobile devices, cloud networking, wireless communication, and power-line communication to provide the user with remote control of various lights and appliances within their home.*

Keyword: - *Augmented Reality, Internet of Things, voice control, touch control, home appliances.*

I. INTRODUCTION

In this project, we are using Augmented Reality (AR) to allow a virtual object to pop out on the screen of the mobile device when the user points his mobile device's camera to a physical object or an image. This allows the user to inter-actively and conveniently control several applications remotely. Besides, AR uses the concept of image tracking, processing and communicating with back- end server (ARCH Server) to control the applications.

The project aims to assist physically disabled and rehabilitated patients in their daily chores and basic routine activities. Our project is targeted at the 200,000 physically disabled in Singapore, approximately 4-5% of our total populations. A problem we are facing in our society is when physically disabled are left home alone without a companion or a domestic helper, as their family members go to work. In addition, there are also many mildly handicapped individuals living alone, either because they value their independence or because they do not have any close family members. One major challenge these people face is how to perform simple household tasks by themselves. Examples of these tasks include turning on and off of light switches and control household appliances.

With the popularity of mobile devices today and the emergence of smart home devices, the general population is becoming more and more comfortable with their use. There have been multiple attempts to use these devices to control and communicate with home appliances remotely; creating what is known as the Internet of Things (loT). However, a key challenge of using these smart devices is that many of their Graphical User Interface (GUI) controls are difficult to be used by the disabled. There is now an emergence of Augmented Reality (AR) technology that is increasingly being developed and used in the mobile platforms, iOS and Android.

We believe using an AR application will greatly aid the physically disabled user to control the home appliances easily from their wheelchairs. Our application, called "ARCH - Augmented Reality Controlled Home" together with ARCHServ (a low power and low cost all-in-one backend server) will allow the user to control a physical switch simply by pointing their smart phone's camera to it from a distance. Different virtual switches will appear when the camera is pointed to different appliances, thus allowing the user to control different appliances easily and conveniently. Compared to at 20 buttons found in current smart phone GUls, these 3D virtual switches will give the user an intuitive yet familiar interface to control their home appliances. We also introduce voice and remote web control features to enhance the operation of these appliances over the mobile device. We strongly believe that with our product and solution, the physically disabled in our society will become more independent and empowered.

II.TECHNOLOGY & HOW ARCH WORKS

In this project, we are using Augmented Reality (AR) using Wikitude SDK [7] to allow a virtual object to pop out on the screen of the mobile device when the user points his mobile device's camera to a physical object or an image.

This allows the user to interactively and conveniently control several applications remotely. Besides, AR uses the concept of image tracking, processing and communicating with backend server (ARCHServ) to control applications.

Other than AR, our group has also implemented features like voice control which uses the native and user friendly Android Speech Recognition and hand wave motion to start an activity. We can also send control data to ARCHServ to activate the General Purpose Input Output (GPIO) pins which will then trigger the household DC or AC appliances (E.g. On/Of . Finally, a mobile web control interface can manually check the status of the household appliances and control them remotely using either an internet or existing home network.

For the backend processing, we use low cost and power efficient Raspberry Pi [4] which runs on Linux to host the web, MySQL and GPIO servers [9]. User's Mobile device can either be directly connected to the home network or operate via the internet, following figure shows the basic architecture of ARCH.

Figure 1.ARCH control system

A.General Home Automation Products

Numerous Home Automation products exist on the market. Most of them are functional only for sub-products within the brand that sells the system as a whole, but some are compatible with other existing "standard" technologies like X10, KNX, Insteon, Z-wave, etc. The main difference between these products is the interface between user and central controller. Some systems require a software running on PC, other are Web-compatible, making it easy to control your home from any mobile or non-mobile device with Internet connectivity. To cite a few of the systems on the market, Belkin's Wemo allows the control of almost anything in the home through an App.

It also can make use of sensors to activate custom events in the house, or use the Web to notify the user about events happening in the house using the IFTTT (If This Then That) service [10]. The magDomus system is another solution for Home Automation; this one is compatible with most existing technologies, which is very practical. The most popular computer software for general Home Automation applications (an open-source software) is MisterHouse, which is customisable, very flexible and compatible with most technologies[11].

B.Central controller(or Brain of system)

Some Home Automation projects have been designed for sending commands within the home only. For this purpose, commands may be received from a short range wireless technology like Bluetooth. This is the case, where the commands are sent from a Smartphone through Bluetooth to an Arduino Mega board as a central controller. Another option is to connect the microcontroller to the Internet to be able to communicate with it from any device that has Internet-connectivity. This can be achieved by the presence of a Web server. The Web Server can run directly on the microcontroller, or on a separate PC with connectivity to the microcontroller, as depicted in [12] or on a router running OpenWrt. One other option is to use cloud services like Cosm (previously called Pachube), whose services (storage of sensor data on cloud servers) can relieve the microcontroller's memory and computational power.

C.Communication protocol between Home Automation Devices(or Brain of the system)

When designing a Smart Home Automation environment, one of the essential concerns is to decide on the communication protocol (or standard) that will link the “brain” to the different devices of the system. We distinguish three kinds of protocols.

Direct Connection

The most basic approach is to use a direct connection of the devices to the microcontroller, like in [12]. Such a procedure is very undesirable in our case, since the Raspberry pi board represents our central unit.This would offer high scalability.

Wired Protocol

X10 is one of the most popular protocols in the Home Automation business, with millions of homes using it around the world, mainly due to the cheap accessibility of its components. Furthermore, most of its units are extremely easy to set up (“plug and play”). In [13], X10 devices are controlled from an Raspberry pi board, making use of the built-in X10 Raspberry pi libraries to send X10 messages through output pins.

The X10 protocol strength lies in its easiness of use and compatibility with Raspberry pi. However, in

[14] the restrictions of X10 are presented. First, collisions may appear if one is using several controllers or repeaters, and X10 doesn't possess the capacity to detect such collisions. This may sometimes lead to altering the status of several devices for no reason. Second, the protocol is considered to be relatively slow. Third, the X10 signal may experience attenuation when there is electrical noise, which is not infrequent. As a result, one of the devices can be accidentally switched on. As a conclusion, X10 should be used for applications that are error-tolerant like lighting for instance, but not for applications like security.

Wireless protocol

Since most RF devices that work on a remote control operate at a frequency of 433 MHz (European Standard), some DIYers have considered the option to reverse-engineer the ASK modulation scheme used to create Raspberry pi libraries that emulate the functioning of the remote control. A system with this capability can mostly control remote sockets, but it is not very flexible and its scalability is questionable.

Other wireless options that are "cleaner" (no hacks involved) include the wireless standard that has succeeded to the old X10 wired technology, which is called Z-Wave. Since it is relatively new, no low cost projects have been found using this technology and it is nowadays mostly integrated in market solutions or products development. Z-Wave is not a completely license-free protocol and may be quite expensive compared to other wireless options.

D.Scheduling Algorithms

Methodologies of problem solving

Here are the basic algorithms to be used to show augmented view of switch:

1. Thresholding:

a. Read the image
b. Convert the Image to Grayscale
c. Threshold the image
d. Complement the image

2. Sobel Algorithm (edge detection)

a. Uses a simple convolution kernel to create a series of gradient magnitudes
b. Uses two convolution kernels, one to detect changes in vertical contrast (hx) and another to detect horizontal contrast (hy).
c.

$$h_x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}, \quad h_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}$$

3. Line fitting:

Step 1: Calculate the mean of the *x*-values and the mean of the *y*-values.

Step 2: Compute the sum of the squares of the *x*-values.

Step 3: Compute the sum of each *x*-value multiplied by its corresponding *y*-value.

Step 4: Calculate the slope of the line using the formula:

$$m = \frac{\sum xy - \frac{(\sum x)(\sum y)}{n}}{\sum x^2 - \frac{(\sum x)^2}{n}}$$

where *n* is the total number of data points.

Step 5: Compute the *y*-intercept of the line by using the formula:

b=y-mx

Where y and x are the mean of the *x*- and *y*- coordinates of the data points respectively.

4.Pose Algorithm:

i. Start with image coordinates of the points we are going to use for pose estimation.
ii. Find model's coordinates of these points.

III.SOCIAL IMPACT AND DESIRED OUTCOMES

We believe that our project could help disabled patients to be less reliant on their caregivers, to bring back their sense of belonging to the society and to control household appliances with ease. ARCH could also be set up at hospitals and rehabilitation centers to help handicaps to access basic stuffs like turning on or off of lighting, air-con and fan. Thus, it will help reduce the burden on nurses and the hospitals' operating expenses. Furthermore, our automated ARCH control system will also enable techies to setup their DIY smart home with plug and play

ARCHServ can be used to remotely control household appliances and monitor the power usage. For instance, when users forget to turn off the appliances while he or she left home, they can switch off these remotely and hence save electrical power and reduce electrical hazards. Our ARCHServ is energy efficient (5V < lA), low cost «SGD 100), support thousands of 1I0s, has easy maintenance, scalable and interoperability with any other platforms that use Web Services. Thus, we believe that ARCH could help household families to monitor and control their electrical usage via web access, switch off appliances with ease, thereby lowering electrical bills and carbon footprints. Lastly, easy navigation and AR interactive operation of electrical appliances will provide users with another dimension of interactive control of their daily routines.

IV.OPERATION

Our users will mainly be disabled wheelchair users with some degree of hand movements and hearing and they could not able to reach out to the household electrical appliances when their caregivers are not around. Our ARCH enabled mobile device will be attached to a wheelchair and the user can easily start the operation by waving his hand in front of the device.

Next, automated voice command will prompt users to interact with the options (e.g. Option 1 for Augmented Reality Control, Option 2 for Voice Control and Option 3 for Remote Web ControL). Users can simply navigate with his voice. With AR control, a user can simply activate the option and point the device camera to the object. An image of a control switch will appear on the screen and user can click on the AR control buttons. For voice control, user can simply select the option of the appliance and control status through voice command.

Lastly, users or their family members can control electrical appliances through a remote web interface when they are away. The ARCHServ is designed to be ready to be used once it is powered, plugged into the user home network.

V.CONCLUSION

In this project, we implemented a system to allow the elderly, disabled and their caregivers to easily control household appliances using AR, voice control & web servers.

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