BLUETOOTH REMOTE HOME AUTOMATION SYSTEM USING WINDOWS AND ANDROID APPLICATION

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Dedicated to my father, Leong Ah Siew and my mother, Wong Kwai Yoke

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ABSTRACT

Home Automation industry is growing rapidly nowadays and enters quickly in this emerging market quickly. A home automation system integrates electrical appliances in a house with each other and includes centralized control. Home Automation can undoubtedly makes life at home much easier. For the millions of people affected by disabilities and also the elderly population, it can make a life-changing difference. This thesis presents the overall design of Home Automation System (HAS) with low cost and wireless remote control. This system is designed to assist and provide support in order to fulfill the needs of elderly and disabled in home. Also, the main control system implements wireless Bluetooth technology to provide remote access from computer and smart phone. Speech recognition voice control method overcomes the limitations of disabled people especially blind and paralyzed. This system remains the existing electrical switches and provides more safety control on the switches by low voltage activating method. The switches status of target appliances is synchronized to all the control system whereby every user interface indicates the real time existing switches status. The system intended to control electrical appliances and devices in house with relatively low cost design, user-friendly interface and ease of installation.

ABSTRAK

Sistem Automasi Rumah industri berkembang pesat pada masa kini dan memasuki pasaran kini dengan cepat. Sistem automasi rumah mengintegrasikan peralatan elektrik di rumah dengan satu sama lain dan termasukan kawalan berpusat. Sistem Automasi Rumah boleh menjadikan kehidupan di rumah dengan lebih mudah. Untuk berjuta-juta orang yang terjejas oleh kurang upaya dan juga penduduk warga tua, ia boleh menghasilkan perbezaan yang dapat mengubah kehidupan. Tesis ini membentangkan keseluruhan reka bentuk Sistem Automasi Rumah (HAS) dengan kos rendah dan kawalan tanpa wayar. Sistem ini direka untuk membantu dan memberi sokongan untuk memenuhi keperluan warga tua dan orang kurang upaya di rumah. Selain juga, sistem kawalan utama melaksanakan teknologi wayarles Bluetooth untuk menyediakan akses yang jauh dari komputer atau telefon bimbit. Aplikasi kaedah kawalan suara mengatasi batasan orang kurang upaya terutama yang buta dan lumpuh. Sistem ini mengekalkan suis elektrik dan menyediakan kawalan yang lebih selamat pada suis dengan kaedah pengaktifkan voltan rendah. Status suis peralatan adalah serentak kepada semua sistem kawalan di mana setiap pengguna dapat ditunjukkan dengan suis status yang sedia ada. Sistem ini bertujuan untuk mengawal peralatan elektrik dan alat-alat di dalam rumah dengan kos yang rendah, reka bentuk yang senang diguna, dan juga cara pemasangan yang mudah.

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LIST OF ABBREVIATIONS

Acronym	Definition
API	Application Programming Interface
BT	Bluetooth
Fig	Figure
GUI	Graphical User Interface
HAS	Home Automation System
Tab	Table
OS	Operating System
PC	Personal Computer
PCB	Printed Circuit Board
PIC	Peripheral Interface Controller

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CHAPTER 1

INTRODUCTION

1.1 Project Overview

The "Smart Home" concept Home Automation System (HAS) has existed for many years. The term "Intelligent Home" followed and has been used to introduce the concept of networking appliances and devices in the house. Home automation Systems (HASs) represents a great research opportunity in creating new fields in engineering, architecture and computing (Huidobro & Millan, 2004). HASs becoming popular nowadays and enter quickly in this emerging market. However, these systems are not always accepted by end users, especially the disabled and elderly due to its complexity and cost.

1.2 Project Objective

- To provide assistance and help to the disabled and elderly people at home.
- To develop a wireless remote control HAS system with low cost design and user-friendly interface.

1.3 Problem Statement

Disability refers to the inability to perform tasks and maintain life roles. *Tetraplegic* people are completely unable to operate a button unless they use their tongue, which is obviously a very tedious task. Simultaneously, *Paraplegic* and *Blind* people deal with a very uneasy situation which couples with locomotion and identification problem. *Elderly* people with impairment may not be disabled but they might face inconveniences in identification and reorganization of various home appliance switches in house.

According to World Health Organization (WHO), there are already 1 billion people experiencing disablility globally in year 2012. The amount has occupied 15% of the world's population and growing due to population ageing. The implementation of HAS at home is one of the great steps towards the integration of severely physically disabled and elderly people. The system is being developed to overcome the problems described above, allowing the end-user to perform home appliances control and accomplish some daily life important tasks by voice control. The application designed for portable smart phones through a Bluetooth wireless network provides users with a simple interface to interact with appliances at home. The application also relies on the implement of speech recognition voice control on personal computer.

1.4 Scope of Work

This project focuses on developing of a main control board prototype and two Graphical User Interfaces (GUIs) on computer and smart phone. The main control board is constructed by a main controller device, Microcontroller (PIC). The microcontroller interacts with GUIs on computer and smart phone in order to control and monitor the function of target home appliances by using relay circuit. The microcontroller connects to sensor in order to monitor the temperature and humidity level at home. The main control board is designed so that complies with the household electrical standards.

Computer GUI is designed with speech recognition system that understands speech and responses appropriate action. The GUI designed on computer implemented Microsoft Agent character to provide virtual real interaction between computer and user. The user interface is designed as simple and powerful as possible, and operates in a self-organized way.

1.5 Brief Review of Methodology

Appropriate method is decided based on the literature reviewed in order to achieve the objective of this project. The methodologies are mainly covered in hardware and software design.

For hardware design, the main control board is constructed by microcontroller, Bluetooth module, relay, and sensor circuit. Microcontroller, PIC acts as the system main core that performs all the control to the target appliances and GUIs. Relay performs the function by activating high household AC voltage by using low DC voltage.

For software design, computer GUI is designed to communicate with the control board. Sensor value and appliances switch status will be synchronized to both computer and smart phone GUIs. The details of methodology will be discussed in Chapter 3.

1.6 Thesis Structure

This thesis consists of five chapters which are Introduction, Literature Review, Methodology, Result and Discussion, and Conclusion and Recommendation. The first chapter is an introduction in which the chapter will provide a brief description of the project is implemented such as the background, problem statement project objectives, project scope, and methodology.

Chapter 2 covered the literature review. Reviews include with the previous similar projects that done by other researchers. This chapter will summarize the strength and weakness of the literature reviewed and come out with the suitable methodology to be implemented to this project.

In Chapter 3, the methodology to design and develop a complete HAS will be explained in details. Chapter 4 presents the result of this project. The result included the simulation and application of the two GUIs. Furthermore, Chapter 4 also analyzes and discusses the result obtained. Chapter 5 concludes the overall project and future work is recommended so that this project function and performance can be further improved in future.

CHAPTER 2

LITERATURE REVIEW

2.1 Wireless Connection

Due to the advancement of wireless technology, there are several different of connections are introduced such as GSM, WIFI, ZIGBEE, and Bluetooth. Several studies have done based on the wireless connection implemented in HAS. Elshafee and K. Hamed implement WiFi technology as a network infrastructure connecting its parts of system [1]. The system can be accessed from the web browser of any local computer in the same LAN using server IP, or remotely from any mobile device. Preject [2 - 4] by Ahmad Arbab Waheed, J. Zhu and J.-K. Guo demonstrate the design and implementation of ZigBee-based HA networks. The project [3] & [4] are Zigbee based voice interactive HA system. The HA system of [2] & [5] are applied with Bluetooth technology in the design. C.L. Hsu designed Zigbee-GSM combination HA system [6]. B. Yuksekkaya designed GSM-Internet interactive voice control HA system [7]. The system implemented microprocessor and GSM SMS control method by a GSM modem. The system [7] mentioned as low cost but the cost of GSM modem and microcontroller is not considered. Also, long term cost by the GSM is not fully accepted by every user.

Based on the study of HAS project done by researchers and developers, K. P. Dutta implemented Microcontroller and a pair of FM transmitter and receiver to establish a RF connection [10]. The simplex connection between control board and controller limited that only one type of input (voice) to the system.

Each of the connection has their own unique specifications and applications. Among all the studies described previously, Bluetooth is being chosen due to its suitable capability. Bluetooth connection is most suitable to be implemented as a cost effective HAS designed for disabled people. Bluetooth with globally available frequencies of 2400MHz is able to provide connectivity up to 100 meters and data rate of up to 3Mbps depending on the Bluetooth device class [8]. In addition, a Bluetooth master device is able to connect up to 7 devices in a "Piconet" [9].

Figure 2.1 below illustrates the example of BT "Piconet" with five Slave devices connect to a Master device. The "Piconet" specification allows multiple control boards designed in the system in order to provide full control to the appliances at home.

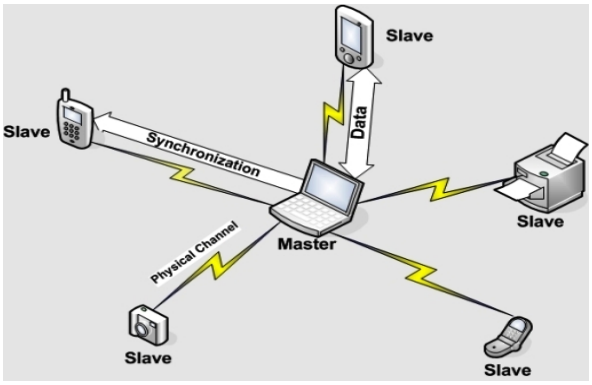

Figure 2.1: Example of Bluetooth "Piconet"

The capabilities of Bluetooth are more than enough to be implemented in the design. Also, most of the current computer or smart phones are come with built-in BT adapter. It will indirectly reduce the cost of this system.

2.2 Previous Similar BT Based HAS Project

Project [7], [11–14] are Bluetooth based HAS. N. Sriskanthan, KY. Lee, S.P. Wijetunge and S. Kumar proposed a Bluetooth based HAS that controls home appliances by a computer's GUI [11 – 14], but it does not provide portable remote function. For system [11–14], all the controls are performed only by the GUI on computer. Project [5], [14], [15] are designed with cellular phone remote control to the system. R. Piyare implemented Arduino Bluetooth board in their HAS project with cell phone remote control [5]. The project stated as low cost HAS system but the cost of Arduino BT board is not the best cost efficient solution. Moreover, the cell phone control is implemented by Symbian OS application. It does limit the users of the system as the Symbian based cell phones in market nowadays are very less. S. Kumar did not mentioned the specific type of phone's OS implemented for their phone application [14]. R. K. H. I. Himshi Kanma mentioned the phone control is designed in JAVA application but it also did not mention the specific phone's OS for the application [15].

From the overall reviews, HAS [5], [7], [10–15] never mentioned about the existing physical electrical switches in their system. Without the switches on the wall, the designed system limited the control only at the GUI. This issue brings inconvenient to the people in the house.

This system design remains the physical switches with the modified low voltage activating method, in order to provide safer physical control to the users compared to the conventional high voltage switches. The BT connection in this system is established by Bluetooth module that directly receives or transmits commands between smart phone and computer. For the GUIs, Windows OS in computer and Android OS in Smart Phone are chosen based on the high user distribution in current market. By considering the flexibility, the main control board is designed with wired and wireless connection. The wired connection is performed by USB HID as secondary connection to the control board. For the wireless connection, the main control board can be connected to either one of the computer or Smart Phone. Besides, the switches status on the board is synchronized in real time to all the connected GUI controllers.

For the speech recognition HA projects review, J. Zhu implements LD3320 voice chip for speech recognition based on SI-ASR (speaker-independent automatic speech recognition) technology [3]. C.-L Hsu used SUNPLUS SPCE061A as speech recognition voice-controller in the system [6].

B. Yuksekkaya, I. Mporas, and H. Jiang designed low cost speech recognition HA systems [7], [16] & [17]. B. Yuksekkaya implements low cost RF module with microcontroller system in the design [7]. The Environmental Control System (ECS) employs a universal remote control by MC68HCll-microprocessor chip and HM2007 voice recognition chip [17]. H. Jiang mentioned that the total estimate cost of the project should be under 200 US dollars [17].

The design of [16] utilizes the open-source HTK toolkit, which implements a state-of-the-art Hidden Markov Models (HMM-based) speech recognizer and low-cost close-talking microphone. Shimper Soda implemented MATLAB application as the voice recognizer [18] and then redirected to a voice recognition engine, Julius [19].

For the projects [3], [16] & [17], implementation of voice chip hardware in the system is able to build a standalone system but costly. Project [16] & [18] implemented voice recognizer software in computer, but it does increase the complexity in launching operation and reinstallation. L. Mporas implemented HTK Toolkit [16] and Shimper Soda implemented MATLAB [18] as voice recognizer required user to prior install and launch those component before the main application is launched. Also, purchase of MATLAB license in [18] is an extra cost to the system.

The voice control feature of this system is designed with Microsoft Speech Application Programming Interface (SAPI) which is an API developed by Microsoft to allow the use of speech recognition and speech synthesis within Windows application. The application compares incoming speech with an obtainable predefined dictionary. The application is supported in Windows XP, Vista, 7 and 8 OS and freely redistributable with any Windows application. The reason of choosing SAPI is because of the built-in voice database in the Microsoft Windows OS and the highest distribution of Microsoft Windows users in the current market.

[20] & [21] implemented internet network infrastructure to connect with the HAS. The internet control methods of [20] & [21] are mainly done by internet browser whereby a domain and web server is hosted. This method is not cost effective because a few bucks required purchasing a domain and the hosting plan usually spends several dollars to serve up the web page. [21] Implemented GSM and Internet to perform long distance wireless HAS control. The system implemented microprocessor and GSM SMS control method by a GSM modem. The long term cost of SMS charged by the telecommunication service provider is not fully accepted by every user.

The email control method is chosen to be implemented in this HAS. The feature is free service from web provider that allows users to monitor and control the home appliances when they are not in the house. By using this service (email), the user can control his or her house appliances from apart, with the availability of internet access. The email parsing function is written in the program (system) to read the command in the received email.

In term of cost, this system implemented low cost microcontroller, Bluetooth module and Relays in main control board. The total cost of one unit of this system hardware is estimated less than RM128 if the Microsoft Windows based computer is available and also computer built-in Bluetooth adapter is excluded. With this low budget, this system is still performed with powerful functions.