Development of Wireless Home Automation System For The Disabled (Deaf, Dumb And Alzheimer) People

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Abstract: *The rapid technological development has brought about continuous reduction in human physical effort and increase in quality of life. This has also brought about increase in the independence, comfort and security of the disabled people through the development of Home Automation System. Various means have been used to support and save the life of disabled at home ranging from GSM based control system, Bluetooth-based application, Android Based method etc. However, there is a need for the development of a low cost, multiple alert systems for the disabled. In this work, a portable IP-based remote control system – WHADDA, has been developed to secure the disabled people with self-automated security devices against fire outbreak and intruder to the house coupled with full control of home electrical appliances remotely. The system was developed based on remote environment and home environment interacting together to ensure a high degree of efficiency. The command interface (on computer system and phone mobile user) component enable the user to control the electrical appliances while home gateway components were used to receive signal from the sensors which interrupt the microcontroller to activate the actuators (e.g. light and alarm). The command component is REST based service over HTTP saddles with the role of relaying commands between interface and the gateway. C# and JavaScript were used at different levels to accomplished different task during implementation phases. The XAMPP software platform was used to create and manage the database. WHADDA provides simple, cost effective and flexible solution suitable for disabled people.*

Index Terms - *Home Automation, Micro-controller, Deaf, Dumb, Alzheimer and Sensors*

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1 INTRODUCTION

According to the World Report on Disability produced by the World Health Organization [1] in partnership with the World Bank, it was reported that 15% of the world's population, are estimated to be living with disability. This percentage is higher than what WHO estimates from the 1970s, which suggested a global prevalence of around ten percent (10%). The most recent figures show therefore a phenomenon which is certainly not marginal, and is growing [1]. Elderly and disabled people are more likely to be exposed to daily life problems than other healthy people. The Smart Home or Home Automation application and development includes various implementation, methods and techniques. Smart home systems are created based on the needs and budget to cater for the system. With technologies available today, efficient integration of this system could be achieved [2]. Smart Home is an integration system, which takes advantage of a range of devices such as computers, network communication as well as synthesized wireless technology to connect all indoor subsystem that are attached to home appliances, household and electrical devices [3]. The Wireless Home Automation System for the Disabled People (Deaf, Dumb and Alzheimer) WHADDA is aimed at providing an environment that is constantly monitored to ensure the householder is safe; automating specific tasks (controlling the electrical appliances); providing a safe and secure environment by alerting the disabled, relatives and appropriate fire security agency of potentially dangerous activities.

1.1 Automation System

The term automation, inspired by the earlier word automatic (coming from *automaton*), this was not widely used before 1947, [4]. Home automation technology and Smart Home appeared very much in science fiction of the 1920s. Home Automation Application Areas include Energy Management, Renewable Energy Management, Driven Smart Home, Health Care Systems and Advanced Multimedia Services, Surveillance and Security etc. [5] Advantages of Home Automation Systems are: System scalability and easy extension Aesthetical benefits and Integration of mobile devices [6].

1.2 Related Works

[7] *Designed and implemented Short Message Service Based Remote Control.* The Short Message Service (SMS) which comprises of hardware and software sections was used. The hardware section consists of Global System for Mobile Communications (GSM) modem module, the control module, the appliance module, the liquid crystal display module and the power supply module. [8] *The Controlling Electrical Appliances through PC and GSM Technology* was also developed. The methodology used involves software development and creating an interface for the controlling, a command is sent through parallel port (TTL) with the C programme to decode the command in "1" as "ON" and

"0" as "OFF". When a message is sent to the GSM modem, the microcontroller decodes the message. Few appliances were used, camera and other features can be added.
[9] Developed *GSM based Control System for Electrical Appliances*. Integration of microcontroller and GSM network interface using C language. MPLAB software was utilized to accomplish the integration. [3] designed *An Independent Living of Person with Disabilities and Elderly People using Smart Home Technology.* Wireless Smart Home for assistive independent living (E/D-WSH) with its approximate cost compared with the Idea Home Automation market. Wireless Sensor Network Smart Home Components.
A designed and implemented a Smart Home for Elderly and Disabled [10]. A simple application of smart home technology. Arduino Mega board and an Arduino Ethernet shield was used to provide communication between the sensors and the microcontroller was used to process and send the gathered data to the system's users, and make the system to be remotely manageable.

2 THE WHADDA SYSTEM

The WHADDA system was divided into three functional parts, namely: Remote Environment, Home Gateway and Home Environment. The Remote Environment represents authorized users who can access the system on their smart phone or tablet or any computer system (web based interface) connected to the internet via Wi-Fi or 3G/4G network. The Home Environment consists of Home Gateway and a hardware interface module. Hardware interface modules are directly interfaced with sensors and actuators. The Home Gateway for the proposed architecture is to provide data translation services between the Internets. The main component of the Home Gateway is a micro Web - server based on Arduino inbuilt Ethernet. Accessing the WHADDA System as illustrated in modules (Figure 1), the disabled people will be able to manage the Electrical Appliances in their homes e.g Lights, Air Condition, Fan etc via the mobile devices or tablets with internet facilities. The disabled people are also secured with the self-automated security devices against major dangerous home incident, e.g. fire outbreak and intruder to the home. The alert system prompt the disabled in respect to the incident.

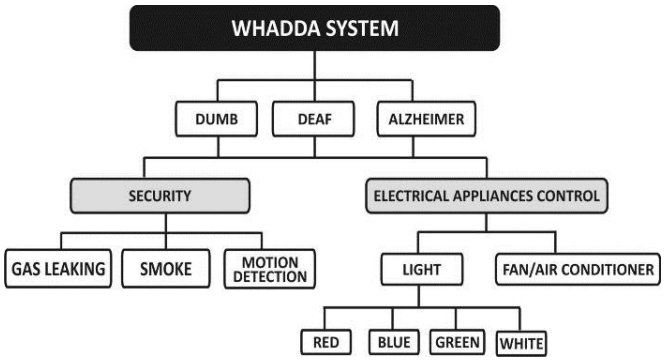

Fig. 1. Modules of the WHADDA System

Let the disability state/condition be represented by an integer variable c, $c \mathcal{E} I$. where c = 1, 2, and 3; such that 1 stands for Dumb, 2 for Deaf and 3 for Alzheimer.
Let G_s, S_s and M_s represent Gas, Smoke and Motion sensor readings from the environment respectively. The corresponding Alerts signal actuator are labelled A_g, A_s and A_m. We represent threshold levels for emergency alert response for each sensor by h_g, h_s and h_m respectively.

a. For Gas leakage detection

The triggered output responses from the microcontroller for gas leakage detection to the disabled are as expressed:

$$\text{If } A_g \geq h_g; \quad L_r \begin{cases} 1, & \forall c,\ c \mathcal{E} I \\ 0, & otherwise \end{cases} \quad Bu \begin{cases} 1, & c=1,3 \\ 0, & otherwise. \end{cases} \tag{1}$$

where L_r is Red light state, 1 for ON, 0 otherwise; and Bu is Buzzer/Alarm sound response. The overall flowchart of the Gas sensor sensing is shown in figure 2.

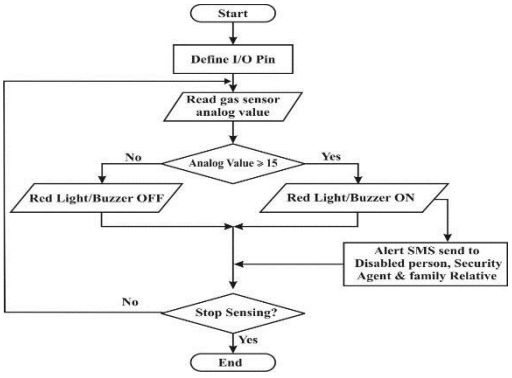

Fig. 2. The Flowchart of Gas sensor sensing

b. Smoke Detections

The triggered output responses from the microcontroller for smoke detection to the disabled are as expressed:

$$\text{If } A_s \geq h_s \quad L_b \begin{cases} 1, & \forall c,\ c\mathcal{E}I \\ 0, & otherwise. \end{cases} \quad Bu \begin{cases} 1, & c=1,3 \\ 0, & otherwise \end{cases} \tag{2}$$

where L_b is Blue light state, 1 for ON, 0 otherwise.

c. Motion Detection

The triggered output responses from the microcontroller for Motion detection to the disabled are as expressed:

$$A_m \geq \text{If } h_m \quad Lg \begin{cases} 1, & \forall c,\ c\mathcal{E}I \\ 0, & otherwise \end{cases} \quad Bu \begin{cases} 1, & c = 1,3 \\ 0, & otherwise \end{cases} \tag{3}$$

where L_g is Green light state, 1 for ON, 0 otherwise.

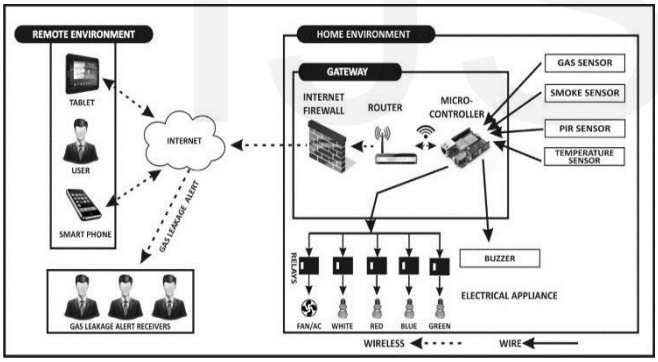

Fig. 3. The WHADDA Architecture of the System.

Similarly, the required lights and electrical appliances can be turn on/off remotely and monitor. The proposed WHADDA architecture is divided into three sections, the Home Environment, Home Gateway and Remote Environment as in Figure 3. Figure 4 shows the overall Circuit Diagram of the WHADDA. At the hardware level, the home automation was designed to validate the workability of the remote control system. Remote Environment provides the following functionalities to the user:

- Remote connection (via internet) to the smart home micro web-server; require server real IP and user authentication.

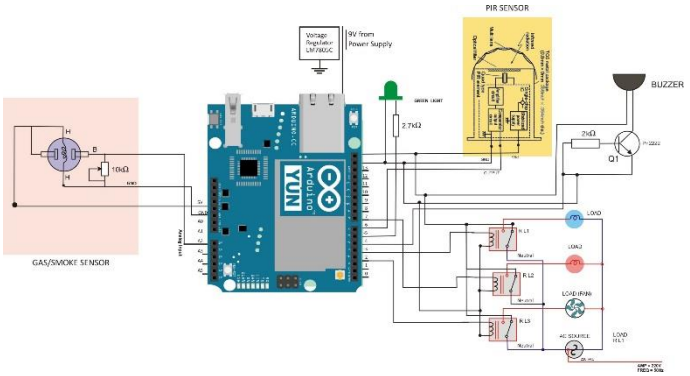

Fig. 4. Overall Circuit Diagram of the WHADDA

- Home appliances control and monitoring
- Password secured.

1. Software Design of the Android Platform App

Phone applications can be developed through several platform, such as Windows Mobile, Symbian, iOS and Android. The Android platform application was developed as most of the phones and handy devices support Android OS. Java programming language using the Android Software Development Kit (SDK) was used for the development and implementation of the smart home application.

The server-side of the software is built on the software platform known as XAMPP. XAMPP stands for X-Cross Platform, A-Apache, M-Maria DB, P-PHP, P-Peril. The software and programming MySQL based database applications with PHP. phpMy Admin was used to create and manage the database. The server response to client and device requests is a JSON (JavaScript Object Notation) object.

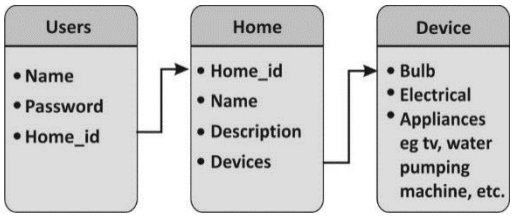

Fig.5. Home Automation database (Relational Model).

The Home Automation database (Relational Model as shown in Figure 5) is the approach to manage data using a structural and language and all data is represented in terms of tuples grouped into relations. i.e. users, home and devices. The Android app was designed to show the switch is the same as the web page on hosting server. It can also read update data on the database by touching the "ON" or "OFF" and appears on the webpage. Writing the Code for the Android Client. The operation of the system includes manually-automated and self-automated modes.

2. System Implementation

The Arduino Yun microcontroller was considered because of it cost advantage compared with inbuilt facilities e.g. Wireless connectivity, two processors etc.; Cross-platform i.e The Arduino programming runs multiple operating systems Windows, Macintosh OSX, and Linux working frameworks); Straightforward (clear programming method); Open source and extensible programming; Open source and extensible hardware and high compatibility with Android.

a. Home Page

For web interface users, the system provides a landing page where navigation to other modules are accessed. Figure 6 shows the home page layout of the user interface. As the case may be, the user can decided to reset/change the password on the web site. The main

Fig. 6. The Welcome Home Page Layout in Desktop Computer for user login.

menu provides navigation to important module the user can use to control the home electrical appliances, mostly ON/OFF mode. For example, if a fire is detected in the kitchen the SMS received by the user relative and security agent as shown in figure 7 with SMS titled "Smart Home Alert" and the body as "Gas leakage Detected".

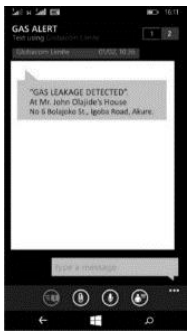

Fig. 7. SMS alert received on mobile phone.

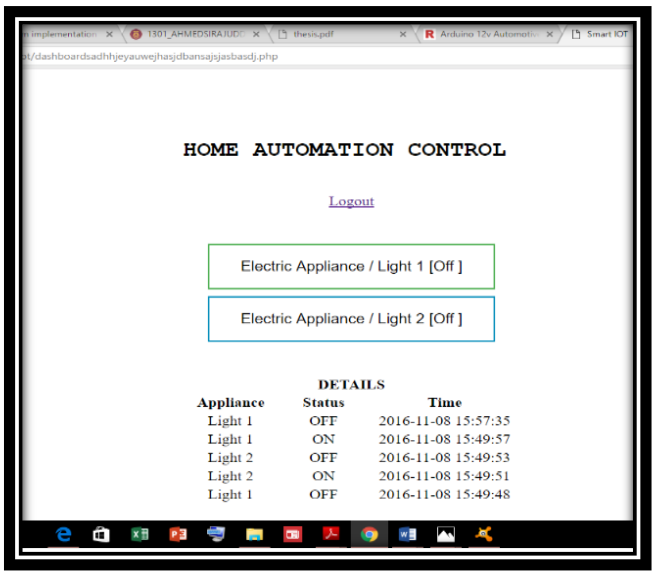

Figure 8. Screenshot of the appliances control online.

3. Result

The microcontroller connects to the internet through Wi-Fi. When the connection is established it will start reading the parameters of sensors like G*x*, M*x*, and S*x*. The threshold levels for the required sensors are set as h_1, h_2, and h_3 respectively. If the sensor parameters are greater than the threshold level then the respective alert/alarm A_s, A_g and A_m will be raised. The figure 8 shows the user interface which will allow us to monitor, manage and control home electrical appliances. The stored database gives the information about the status of the various electrical appliances like light, fan etc. which we can control remotely.

4. Performance Analysis

The system was compared with the others methods of connecting home automation system. The Zigbee, Inferred (nRF24LOH) and Bluetooth. The error rate differences are shown in Table 1.

Table 1: The error rate of different wireless connection

S/N	Wireless System	System Failure (50 Trials)	% of Error
1	Zigbee	1	2%
2	nRF24LOH	7	14%
4	Bluetooth	4	8%
5	Wi-Fi	0	0%

Since GSM requires much power and cloned SIM makes it easy to hack, it is not given here for comparison. Since the performance of this research was done with 50 trials and error, the result is analyzed graphically figure 9.

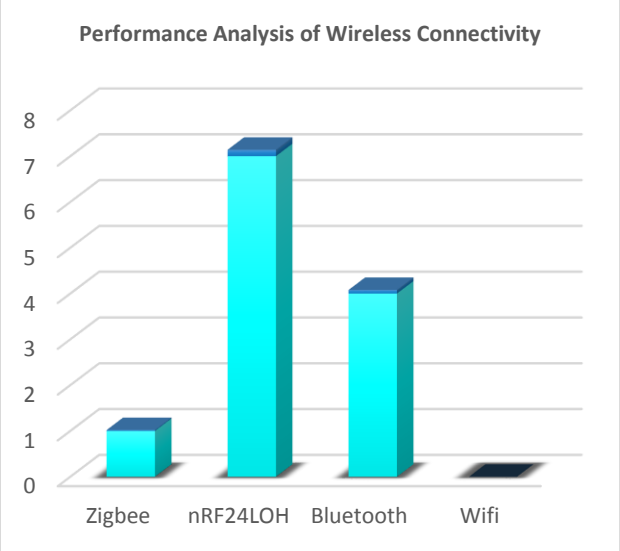

Fig. 9. The graphical representation of performance analysis.

Figure 10 shows the time interval that it takes the home appliance to ON/OFF when control remotely. Fourteen trials was made, it takes average of eleven seconds for the Electrical home appliances to be ON/OFF. The practical experimental setup of the system is shown in figure 11.

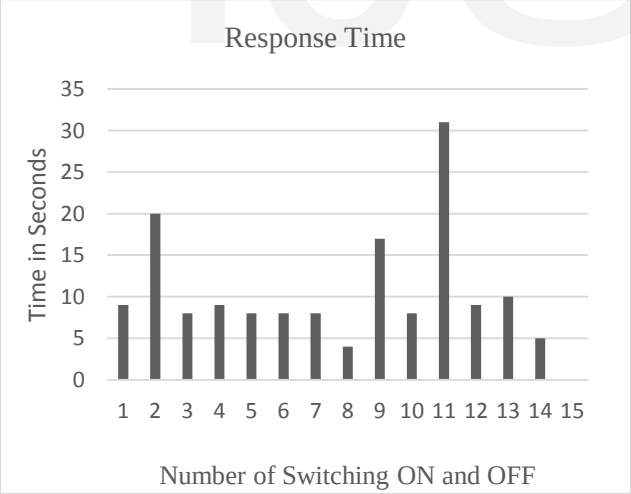

Fig. 10. The time interval that it takes the home appliance to ON/OFF

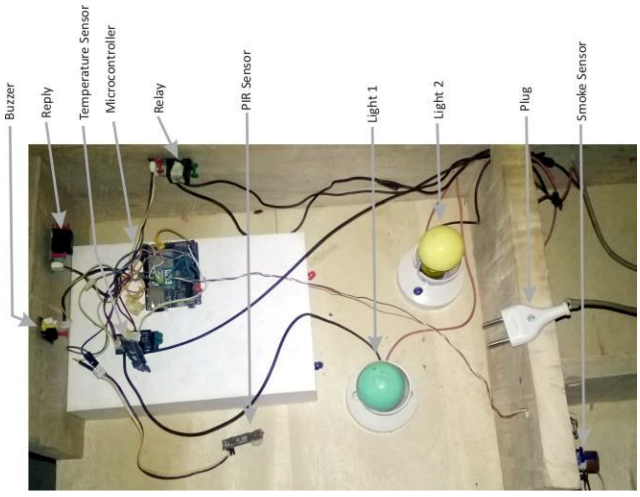

Fig. 11. Experimental Setup of WHADDA

8. Conclusion

The goal of the research work to develop Wireless Home Automation system for Disabled (Deaf, Dumb and Alzheimer) – WHADDA was achieved. The full confidence and peace of mind for both the disabled and their family members to enjoy the comfort of living at home. The proposed technique provided in the automated system has two operational modes, manually-automated mode technique in which home appliances were monitored and controlled using cellular phone or tablet through Wi-Fi communication technique. Self-Automated is the second mode that made the microcontroller capable of monitoring the sensor data of gas, smoke and motion and temperature sensors. For gas leakage or smoke detection, sensor which are actuated according to the specification automatically send danger emergency SMS and email to the user help and emergency agencies for prompt respond. The implementation system was low cost, flexible and can be expanded and scaled-up. The system as a framework can be expanded to include more options like capturing the photo of a person moving around the home and storing it onto the cloud, reduced response time and the using of voice recognition system for lame. All at a reduced cost. The system can be implemented at home, hospital for disabled people, to monitor environment and industries where human invasions is impossible or dangerous.

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