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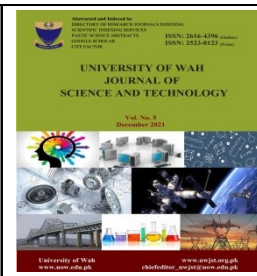

Design and Development of a Cost-Efficient Voice Controlled Appliance System for Quadriplegia Patient

Waqar Ahmed, Ayla Safdar, Sohaib Abdullah and M.Ammar Masood

***Abstract*—In present world many people are suffering from quadriplegia that is hands and legs disability. The patient become dependent on others even for controlling room appliances. To bring ease in their life different manual methods are designed which are quite difficult for disabled persons. However, increase in use of home automation in recent times to control electrical appliances yet these devices are not affordable from every class of society. Disabled people especially in less developed country wish for low cost and highly efficient product. In our project we develop a voice-based load control system for quadriplegic patient which gives reliability and simple method of controlling all the electrical loads using voice commands. Proposed system comprises of Raspberry pi 4 that is associated with Relay module. The voice from user is taken as input through USB microphone and converted in to message through Google API for controller processing which leads to load triggering. The uniqueness of this proposed system is that the available systems is appropriate for individuals of each class of individuals and is user friendly.**

***Index Terms*—Quadriplegia, Raspberry-pi 4, Relay module, USB microphone, Google API.**

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I. Introduction

CONTROLLING of the electrical loads is very important in our daily life. Electrical loads are accessible with the help of control switches. The working of switches may or may not be manual. The commonly used electrical switches are having electromechanical strip. This is connected with outside circuit and having minimum one complete arrangements for electrical contacts in a circuit. The inventers are trying to invent some basic standards to control electrical loads.

These days many smart systems have been playing important role in the part of people daily routine. Using the way of modern technologies, different sensors, processors and phones the smart home systems generally facilitate the house hold control, observing home energy and security system.

Generally, conventional home wiring systems comprise of appliances such as fan, bulb, connected to power supply with a switch between them for controlling system that electrical appliances. Voice based controlling load has served in the field of automation since a long time. Voice based load control system generally provide ease of controlling electrical devices and hence provide comfort and bring ease in the life of disabled persons. Home devices can now be controlled using a single remote and there is no need to get up for switching the electrical devices and make comfortable for the disabled persons.

In many applications, speech recognition concept is used including google voice searching for speech to text conversion. Speech recognition modules are used to build these applications. As every person has desire of a

comfortable life. Home automation system is very helpful in the current world for controlling electrical loads and other household appliances.

This framework is especially essential for disabled persons to carry on with an agreeable life. They can handle gadgets and loads in home utilizing the voice orders handily contrasted with utilizing a controller unit which they need to convey unsurpassed. Taking voice-based home automation to an unheard-of level would imply that you will actually want to controlthese gadgets without squeezing a catch or utilize a solitary far off or any actual element to control the electrical loads that help hands and legs disabled people in day-by-day life. There are different methods proposed by researcher on voice control of using different techniques discussed below in literature.

In a voice-controlled system consisting of Firebase, MIT App Inventor, WEMOS D1 microcontroller equipped with an embedded micro-controller and Wi-Fi onboard shield. The limitation of the system is that it must be connected to the internet, if there is no internet network then all devices in the house cannot be controlled [1].

Many efforts have been made in order to developing voice control for home automation. In paper overviewed the home automation and its related terminologies related to it, a model based on this concept in his proposed model with bluetooth and AT-Mega 2560 as base [2]-[3].

Node MCU to control the home appliances through a voice based or text-based control. It is very cheaper since high performance and least cost equipment's are used. This application is not bounded by distance constraint [4].

In many applications including iPhone's voice-operated assistant Siri, Google Voice Search, automated phone queues this concept is used. Accuracy of the voice command introduced at varied distance, the voice command with 95% accuracy when 4 m apart and increased the accuracy [5].

A model that has a voice processing application is listening for the keyword. Once the keyword is detected, the application starts recording the user request. After the ending of the command is detected, the recorded audio file is sent to the voice recognition cloud service. System accuracy and response times were measured, and it is confirmed that are suitable for practical purposes [6].

System that uses smart plugs, smart power strips smart cameras, and a digital assistant such as Amazon Alexa, Google Assistant, Microsoft Cortana, Apple Siri, or Apple Siri to capture voice commands [7].

Model in which offline recognizer pocket sphinx for speech to text recognizer wit MQTT message used for efficient working [8].

System utilized Raspberry Pi's network and DNS settings, using the Raspbian operating. System in order to connect mobile devices. The system was able to automate the five appliances inside the room [9].

Smart home system that can be controlled locally by using the Bluetooth technology. In addition, the system can be operated by a far remote location by using the GSM technology. The home appliances with the designed Android application by using the voice, Bluetooth and SMS inputs [10].

The method able to modernize the existing home appliances and add voice command feature to almost any legacy home appliance at affordable prices. The system operates on an android phone [11].

A system is proposed keeping in view the quadriplegia patients in order to make them self-dependent and in order to them cost care.

II. PROPOSED DESIGN

The building blocks for creating complete hardware consisting of a Raspberry-pi 4 microcontroller, Relay module, USB microphone, Google API.

Developed hardware operation mainly depends on the surrounding condition and availability of internet, whereas, triggering delay is controlled by raspberry-pi 4 Microcontroller. The block diagram of voice-based load control is shown in Fig.1.

Microcontroller will naturally act as the control unit. Constant power supply of 5V DC is provided to microcontroller. Microcontroller peruses the voice detected utilizing microphone (attached to it through USB port) and afterwards utilizing Google API command is processed.

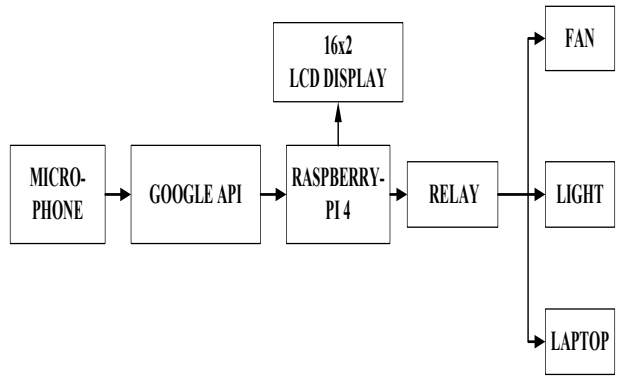

Fig. 1 Block Diagram of Voice Based Load Control

triggering of relay through command Manuscript received: August 16,2021; Accepted: December 27, 2021

III.

When the voice is detected, it is processed to be converted in text for controller, which match the given set of commands if it matched the process is continued if not then the process gets terminated and the system get back to start up position where its ready to take in command input. The flow of processes will be voice will come it is converted to text if it matches the activation command, product get activated and becomes ready to get load triggering command. Again, voice input is taken and after processing the signal is generated by the controller and the rely is triggered on and off respectively.

The commands on system are shown in Table I.

Table I
Triggering commands

COMMANDS	PURPOSE
'Hello'	To activate the listening.
'Light on'	To turn on light.
'Light off'	To turn off light.
'1'	To turn on fan.
'0'	To turn off fan.
'Laptop on'	To turn on laptop charging.
'Laptop off'	To turn off laptop charging.
'Power'	Turn all loads on.
'Shutdown'	Turn all loads off.

IV. SOFTWARE IMPLEMENTATION

Proposed system is designed & simulated using Proteus software.

A. Controller Discussion

In the simulation raspberry model 3 was used as controller. Four pins were used but due to restriction of connection directly made through port available in library. Ports were given name of the dedicated raspberry-pi pin number and all the connections are made to them.

B. Triggering Module Discussion

Relay module is designed manually by using component which it contains. The components are used as follows: Transistor, SPDT, transistor, resistor's, 5V supply and ground.

C. Voice Input Discussion

Mic is unavailable in library of Proteus software. In order to perform simulation directly one bit and zero bit is given input to the controller through coding. As the bit basically represent activation and deactivation of command the relay start getting triggered.

D. Load Discussion

Bulbs connected to relay module designed act as real time load's representative. The continuous turn on and off of load represent the proper working of system. The discussion above of model simulation scheme and its component is shown in Fig 2.

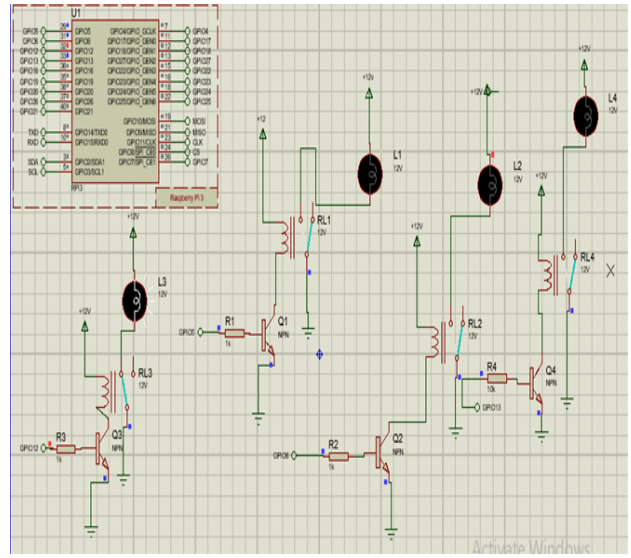

Fig.2. Software Simulation of System

V. HARDWARE IMPLEMENTATION

Hardware is developed inside a 5x5 inches box. USB microphone is connected to the USB section of the controller, which has dedicated space inside the box. Proper 16x2 panel LCD is connected to dedicated pins of controller in order to provide interface between user and system. A control panel is provided in the system in form of brightness and contrast control variable resistor so that it can be adjusted according to need. Complete hardware is shown in Fig 3.

A. Operating Procedure of System

The hello command activates the system and it become ready to take command. Now the load control command is given which is processed and action signal is passed accordingly. Commands are discussed in Table I.

B. Relay Working

When the commands get matched signal is transmitted to the pin of relay connected to the pin of controller. The

relay on receiving signal turn on or off the load with the change of position from normally open to normally close or vice versa.

C. LCD Working

When the voice will be detected it will be analyzed and the speech to text conversion result will be displayed on the LCD screen with the indication of next command to give or if not recognize indication is given.

D. Error's Alerts

With the problem of net or internal issue the system automatically go into halt state and display the specified error accordingly as discussed below:

1) Net Problem

If it is being displayed on LCD it means network connectivity problem.

2) Unknown Problem

If it is being displayed on LCD it means circuit connection problem.

3) Not Recognize

When command is not recognized.

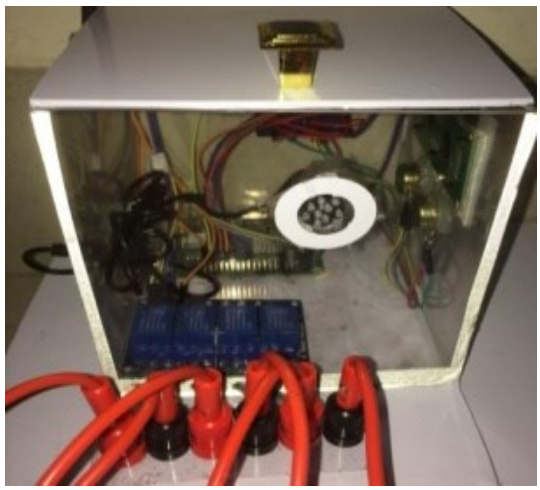

Fig.3(a) External View

Fig.3. (b) Internal View

VI. RESULTS AND DISCUSSION

System tested on different conditions based on distance from which voice commands by the user to microphone. Also processing time of commands

A. Processing Time Tasks.

B. In Fan Air Absence.

C. In Fan Air Presence.

D. Two Noises at a Time.

Here is collected detail data for all the above cases which display performance, efficiency and time consumption.

A. Case 1: Processing time of Tasks

In this case the system processing time is observed in order to check speed of execution and feasibility. Time taken by all task performed in order to execute a single command is measured.

Result shown in Table II.

Table II

Processing time of different task.

PROCESS NAMES	TIME TAKKEN
Initializing time	2.5 seconds
Activation word recognition time	4.4 seconds
Display LCD time	5.7 seconds
After activation recognition time	12.3 seconds
Best scenario	30.4 seconds
Worst scenario	50 seconds to 1min

B. Case 2:In Fan Air Absence

In this case, system was tested in the absence of air so that accuracy can be examined with which it recognizes the command when the fan air is not distorting the voice. All voices absence is made sure, effect could be observed.

Tested voice commands from different distances and observed that how a system detected the voice commands and how much repetition of voice commands is required.

In distance from the point of placement of system of 1-8 feet all commands were recognize correctly with all action were performed correctly. When distance reaches 10 feet the command needs to repeat one time.

Result shown in Table III.

Table III

In fan air absence system performance

(S=Status, R=Repetition of command required, D=Detected, N= Not detected, C=Chance.)																
Distance (Feet)	COMMANDS															
	Light on		Light off		1		0		Laptop on		Laptop off		Power		Shut-down	
	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R
1 Feet	D	0	D	0	D	0	D	0	D	0	D	0	D	0	D	0
2 Feet	D	0	D	0	D	0	D	0	D	0	D	0	D	0	D	0
3 Feet	D	0	D	0	D	0	D	0	D	0	D	0	D	0	D	0
4 Feet	D	0	D	0	D	0	D	0	D	0	D	0	D	0	D	0
5 Feet	D	0	D	0	D	0	D	0	D	0	D	0	D	0	D	0
6 Feet	D	0	D	0	D	0	D	0	D	0	D	0	D	0	D	0
7 Feet	D	0	D	0	D	0	D	0	D	0	D	0	D	0	D	0
8 Feet	D	0	D	0	D	0	D	0	D	0	D	0	D	0	D	0
10 Feet	N	1	N	1	N	1	N	1	N	1	N	1	N	1	N	1

C. Case 3:In Presence of Fan Air

In second case tested the system in the condition where there was proper effect of fan air. Now the system is affected by fan air so performance of system also varies with respect to the other case.

Tested voice commands from different distances and observed that how a system detected the voice commands and how much repetition of voice commands is required. Collected data as shown in Table IV.

Table IV

In fan air presence system performance.

(S=Status, R=Repetition of command required, D=Detected, N= Not detected, C=Chance.)																
Distance (Feet)	COMMANDS															
	Light on		Light off		1		0		Laptop on		Laptop off		Power		Shut-down	
	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R
1 Feet	D	0	D	0	D	0	D	0	D	0	D	0	D	0	D	0
2 Feet	D	0	D	0	D	0	D	0	D	0	D	0	D	0	D	0
3 Feet	D	0	D	0	D	0	D	0	D	0	D	0	D	0	D	0
4 Feet	D	0	D	0	D	0	D	0	D	0	D	0	D	0	D	0
5 Feet	D	0	D	0	D	0	D	0	D	0	D	0	D	0	D	0
6 Feet	D	0	D	0	D	0	D	0	D	0	D	0	D	0	D	0
7 Feet	D	0	D	0	D	0	D	0	D	0	D	0	D	0	D	0
8 Feet	D	0	D	0	D	0	D	0	D	0	D	0	D	0	D	0
9 Feet	N	1	N	1	N	1	N	1	N	1	N	1	N	1	N	1
10 Feet	N	1	N	1	N	1	N	1	N	1	N	1	N	1	N	1

D. Case 4:Two Noises At A Time

In third case system tested in the condition where there was effect of fan noise along with other noise as well. Now the system was affected by both fan air as well as another any type of noise. So, performance of system also varies with respect to the other case.

Now tested voice commands from different distances and observe that how a system detected the voice commands and how much repetition of voice commands is required. We again collected data as shown in Table V.

Table V

Two noises at a time system performance.

(S=Status, R=Repetition of command required, D=Detected, N= Not detected, C=Chance.)																
Distance (Feet)	COMMANDS															
	Light on		Light off		1		0		Laptop on		Laptop off		Power		Shut-down	
	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R
1 Feet	D	0	D	0	D	0	D	0	D	0	D	0	D	0	D	0
2 Feet	D	0	D	0	D	0	D	0	D	0	D	0	D	0	D	0
3 Feet	D	0	D	0	D	0	D	0	D	0	D	0	D	0	D	0
4 Feet	D	0	D	0	D	0	D	0	D	0	D	0	D	0	D	0
5 Feet	D	0	D	0	D	0	D	0	D	0	D	0	D	0	D	0
6 Feet	D	0	D	0	D	0	D	0	D	0	D	0	D	0	D	0
7 Feet	D	0	D	0	D	0	D	0	D	0	D	0	D	0	D	0
8 Feet	D	0	D	0	D	0	D	0	D	0	D	0	D	0	D	0
9 Feet	N	1	N	1	N	1	N	1	N	1	N	1	N	1	N	1
10 Feet	N	1	N	2	N	1	N	2	N	1	N	2	N	1	N	1

The total area cover by the microphone is at least 10sq meter. When there is some noise involved like fan there is little effect on accuracy, but it performs efficiently. The performance of system also affected with respect to distance from user to system as discussed.

The working of whole system also depends upon the internet speed because Google API speech to text conversion depends upon the internet connection and environmental condition like high temperature etc.

VII. CONCLUSION

Propose system will enable quadriplegia patient to be operate electrical appliances through voice their speaking ability. It will not only result in improving quality of life

of patient but also prove to be economical. As from result discussion it can be concluded that it is not only less costly but also has best performance even in non supportive condition. System maintenance and installation is not a difficult task. Variety of different methods of voice-based load control being used but involves high cost of equipment and not highly efficient. Voice control on other home automation methods has an edge because of fact that it reduces the human effort to almost zero. The proposed system has its own mind-boggling sway over these patient as it creates a feel of self dependency in them.

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