Low-Cost Android App Based Voice Operated Room Automation System

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***Abstract*— Smart home appliances with a host of different control features have become a popular research area. Most of these systems are expensive and require a complete replacement of the existing equipment. The proposed method will be able to modernize the existing home appliances and add voice command feature to almost any legacy home appliance at affordable prices. This framework will be very helpful for the needs of elderly and handicapped patients due to its minimalistic technological know-how requirements. The system operates on an android phone, connected over Bluetooth to a local home automation node. The app recognizes speech commands and transmits it to the node. Based on the devices connected to it, the node searches for keywords in the command and takes a control action.**

Keywords— Voice control, home automation, Bluetooth control, command recognition, IR transmitter.

I. INTRODUCTION

With the increase in processing power of handheld devices, speech recognition has become a common feature in smartphones. Some of the popular applications include the Apple's SIRI, Google Voice Search and Microsoft's Cortana. Over time this technology has been used for Home Automation Systems (HAS). Primary objective of HAS is to provide comfort and convenience to the user. It can be especially helpful for the elderly and handicapped patients by giving a remote access as well as simpler voice command facility. The user can operate different home appliances like fans, lights, air conditioners, televisions etc. from a single device wirelessly by just speaking out what they want it to do.

At present, there are many types of commercially available home automation systems. But, they have some crucial challenges which are high ownership cost, need to replace all legacy home appliances with new compatible ones and complicated user interface making it unsuitable for elderly people. To address these problems a low cost Bluetooth app based HAS has been proposed. Modern smartphones, being fairly advanced and cheap, serve as a perfect platform for the high computationally demanding speech recognition. This is further improved because of openly available APIs for speech recognition. The app is designed to send the recognised speech to the HAS node via Bluetooth protocols. The HAS node then runs it through an algorithm developed to make use of a key-word-search mechanism to determine the intention of the user from the recognised speech. This is then used to send out control signals to the different devices. For simpler electrical devices such as fans and lights, signal is sent to a relay system, whereas for much complex systems that can have an IR (infra-red) remote facility, an IR signal is sent out form the node using an IR emitter.

Existing home automation systems developed around the android platform are mostly developed with either IoT [1] based (using WIFI as the mode of communication), or basic toggle switches on app screen [2]. Voice controlled automation has been implemented with high end processing systems such as Kinect [3] and a PC to process the speech. All this method makes the system more expensive as well as complicated to be used with minimalistic technological know-how.

Using MATLAB, P. Gupta [4] had developed a voice recognition module. But this makes the system expensive as MATLAB isn't open sourced. The need for a PC for the processing further adds up the costs.

Kumar, Sushant, and S. S. Solanki [2] have implemented the use of android platform for the speech recognition for home automation. This is limited to exact voice commands being given by the user and only switch on or off the power supply to the devices involved. Adding a feature for command recognition from any sentence, as well as the feature to control other electronic appliances would increase the usability and flexibility of the system. Present day android devices have also evolved considerably in terms of processing power as well as noise reduction for audio capture as well as speech recognition to make the system much more cost effective and reliable.

For this work, a standard room with a fan, two lights, a TV and an air conditioning unit has been considered and experimented with.

II. SYSTEM ARCHITECTURE AND IMPLEMENTATION

In order to maintain the low cost and ease of use, the entire system has been developed around an open sourced Arduino platform. The programming was mostly done on the Arduino integrated development environment and the libraries used are open sourced also. The basic block diagram of the system is shown in fig.1.

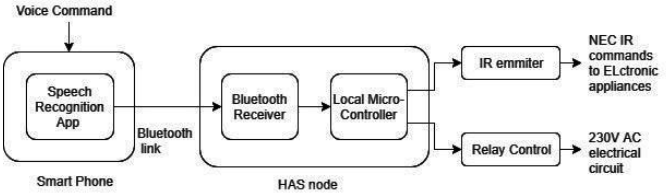

Fig. 1 : Block Diagram of the System

A. Speech recognition app

Google's android operating system for smartphones has a very powerful and accurate speech recognition API (Application Programing Interface) to generate text from speech captured from the microphone. The app ARM-Voice is a free app produced by SimpleLabsIN [5], that makes use of this speech recognition API and transmits it over Bluetooth. This app is designed to transmit data with a constant baud rate of 9600 bauds. The average time taken to recognise the command is about 2 seconds, but this changes from one smartphone to another. The string that is transmitted has a specific format.

* {recognised speach}#

Example: if an input command is "please switch off the fans" the app will transmit "*please switch off the fans#". Fig.2 shows the interface of the app screen.

Fig. 2: android app screen

B. HC-06 Bluetooth trans-receiver

To receive the speech data, Bluetooth trans receiver is used. For this purpose, the HC-06 from Olimex ltd [6]. is used. This particular module is chosen due to its reliability, low cost and simple interface with microcontroller via a serial interface. It is based on 2.4 GHz digital wireless Bluetooth transceiver (CSR BC04 Bluetooth technology) and has a build-in 2.4 GHz antenna. The current firmware on the module allows user to set their own device name and password via AT commands.

C. ATmega 328 based Arduino microcontroller

The ATmega 328p [7] is a powerful general purpose RISC architecture based AVR microcontroller. It features a low power consumption 8bit CMOS architecture. The ATmega 328p based Arduino Uno or Arduino Nano has been chosen for the prototyping purpose. This operates at 16 MHz and has 14 digital I/O pins and a single serial communication port making it ideal for this application.

The speech data received by the Bluetooth is transferred to the Arduino via serial interface. The data is run through a keyword search algorithm on the microcontroller. The keywords, if matched, are then used to trigger the control actions to the relay board or the IR emitter.

D. Relays and electrical isolation

Relays are electromechanical switches that can be used to switch high voltage/ current circuit by a lower voltage circuit, while providing complete electrical isolation. Here, a 230V electrical appliances are to be controlled with a 5V DC based control circuit. As the relays use considerably higher current (about 50-100mA) than the max output current of the micro controller, a BJT current amplifier is used to drive them. Circuit diagram for the relay circuit is shown in the Fig.2.

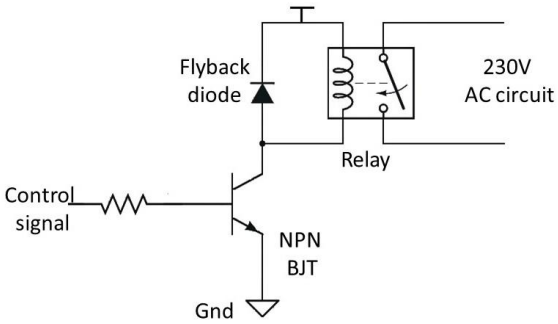

Fig. 3: Relay Circuit diagram

E. IR emitter

Infrared remotes are one the cheapest and simplest form of remote control device used in most home appliances. A standard IR remote works by encoding data into a 38 KHz carrier signal, and transmitting it via an infrared LED. This is then picked up by a photo diode (like the TSOP28238). The data is decoded using a microcontroller and then a control action is taken. Here, the encoding of the command data is done using the standard Arduino library "IR_remote_master.h" [8]. The data that needs to be sent for every command is pre stored in the memory of the microcontroller.

III. COMMAND RECOGNITION ALGORITHM

The command is sent from the app via Bluetooth. The proposed system doesn't need the received command to be a specific statement to be a valid command. The algorithm uses a keyword search method to look for words that are necessary to make a command. This makes the system more flexible for the user point of view. For a command sentence, a buffer of 10 words is used. The words are then compared with previously stored words and flags are set on a successful comparison. These are then used to make sense of the command. For example, to switch on a fan, the presence of the words "switch", "on" and "fan" in the command, irrespective of the order and presence of other words, gives us an indication that the command is intended to switch on the fan. The flowchart of the algorithm is shown in fig. 4.

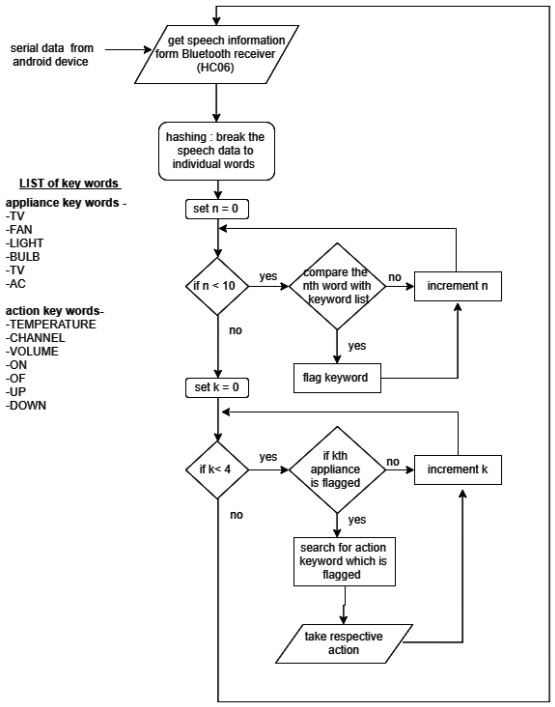

Fig. 4: flow chart for the algorithm

The key words, command list and the method through which the actuation takes place is given in Table 1. These are used to control a few commonly used appliances in a room. Legacy appliances like TV and AC will be mostly operated using an IR remote emitter, while basic home appliances like lights, bulbs and fans will be operated using relays to switch them on and off.

TABLE 1: Command List and Actuation Method

Appliance	*Command Category*	*Action*	*Actuation On*
Fan	Switch	On/ Off	Relay
Light	Switch	On/ Off	Relay
Bulb	Switch	On/ Off	Relay
TV	Switch Volume Channel	On/ Off UP/ DOWN UP/ DOWN	Relay + IR Transmitter IR Transmitter IR Transmitter
AC	Switch Temperature	On/ Off Up/ Down	Relay +IR Transmitter IR Transmitter

IV. EXPERIMENTS AND RESULTS

The experimental setup is shown in fig. 5. The system is implemented and tested with a Xiaomi mi 4i, running Android Lollipop (5.2). The system is tested with command generated by IBM's Watson- text to speech service [9]. To test the accuracy in different noise conditions the command is set at 10dB and white noise was introduced, using the audio editor software Audacity [10]. Noise level is varied from 0 to 5dB. The distance between the source and android device is varied from 10 cm to 1 m. At each distance, 10 readings are taken to find the accuracy of the system. Fig. 6 shows the plot of the accuracy of the system with the variation in distance at different noise levels.

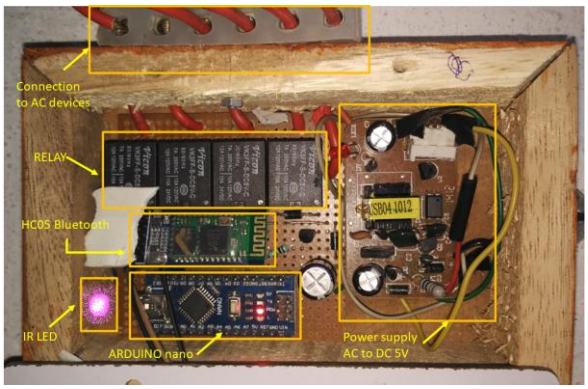

Fig. 5: Experimental setup

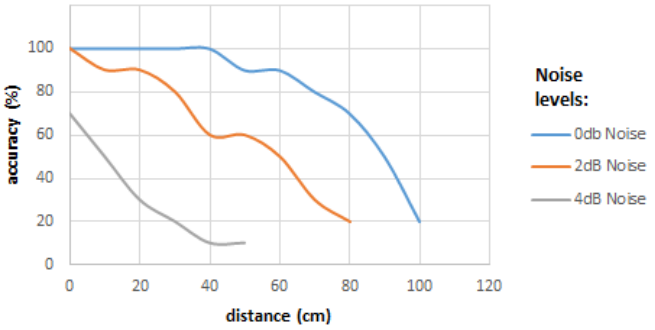

Fig. 6: graph of accuracy vs distance

It is observed that the app shows common problem with identification of similar sounding words, such as "of" and "off" was almost always detected as the other. Similarly, plural form of words and key words are also interchanged by the app. On long term usage, it is found that similar meaning words are often interchanged in command sentences. For example, "next", "previous", "reduce", "increase" and "decrease" are often substituted for "UP" and "Down". To mitigate for this error, the program is modified to accommodate and flag similar sounding, similar meaning and plural form of words, to set flags for the same variable.

V. CONCLUSION

From experimental results, it is observed that the system has good immunity to noise, due to the use of well-developed

voice to text algorithms in modern android smart phones. The ability to interpret the command for any sentence spoken by the user sets this method apart from earlier works. The overall cost of the setup is under 1000 INR (about 15 USD). The system will be very useful for elderly and handicapped patients due to its simplicity.

This work can be easily expanded to be a part of a larger networked home automation system. This subsystem can be used as a second node to take input commands from a user. Further work can be done to make a dedicated android app for the system instead of using a generalized app. This will enable to add more specialized features from the app itself.

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