A Review on Home Automation Using Voice Recognition

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Abstract – *Home automation is the concept of making any home "smart". A smart home is a network of interconnected devices which can be controlled by the user, in the most convenient way possible. This paper reviews various ways in which people can automate their homes. An ideal home automation system must provide a balance between cost, robustness, reaction time, processing power, flexibility, security and convenience among others. This review paper elaborates the different methods of integrating voice recognition technology in home automation systems.*

Key Words**: **Home Automation, Voice Recognition, Wireless Technology, Cost, Arduino, Artificial Intelligence, Bluetooth.

1.INTRODUCTION

Home automation has recently come into the limelight and thus has undergone large scale development. Everything from lights and gas stoves to a garage door can be controlled using a central panel in the house or through wireless devices using an application or even voice commands. It has been a huge advancement in technology, where it proves very useful in big houses or for the differently abled such as for the blind etc.

It goes from basic switch controls that turn the lights on/off to creating different environments in the house based on requirements or mood, calling an Uber cab for you, controlling the HVAC systems of the house, Audio Visual entertainment systems etc. and many other advanced functions in the technological aspect.

Home automation is not only a luxury, but for certain demographics like the quadriplegic, the elderly and the differently abled, it can be of great assistance. A home automation system makes them independent and self-reliant to a certain extent.

The current market leaders in home automation technologies are Google Home, Amazon Echo, Alexa, Wink Hub, Logitech Harmony and Apple HomeKit. All of these are only the control hubs and require the purchase of home automation compliant appliances to function. Examples of such appliances are Phillips Hue, Nest Thermostat, Canary, Sentri, Google Cast and Avion.
The papers we studied did not rely on such devices. Instead they built their own test network of devices using cost effective components like micro-controllers and relay circuits on which they ran their respective algorithms.

2. LITERATURE REVIEW

Mohamed S. Musbah[1] et.al adopts a client/server model and is designed to control home appliances using voice recognition technology. The model consists of three main components

i)   Front End User Device: Can be any mobile device such as a laptop or smartphone with a good microphone and voice recognition feature. The device used in this paper is a Windows 7 PC which contains an inbuilt Windows 7 Speech Recognition Software.

ii)   Home Server: Can be any laptop or a computer which consists of a Wi-Fi adapter and a Windows operating system (Windows XP or higher).

iii)   End User Device: Consists of two parts, Arduino Uno to process the incoming commands and the home devices.

The devices considered in this paper are a D.C. fan and LED lights. The front-end device primarily contains two voice commands namely start listening and on/off. The device application establishes a connection to the home server via a wireless ad-hoc connection (TCP/IP transmission protocol). The home server in turn acknowledges the connection and receives commands from the front end interface while opening a connection to the microcontroller and then forwards the command to it. Now the Arduino uno implements the given command according to the target device. The working is illustrated in the fig [1].
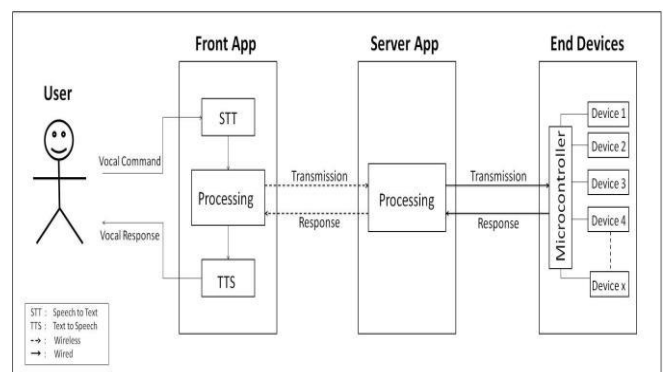

Fig-1: Working Model

Sushant Kumar[2] et.al approaches home automation through voice recognition and user interface control. Both functions are carried out using a smartphone. The interfaces interact with each other using efficient Bluetooth wireless communication.

End user control consists of a combination of google voice API and the AMR voice app which understands the voice commands. The Arduino Bluetooth control serves as the touch based application with support for up to 8 devices.

i)   AMR Voice:
   a) Connect Bluetooth through the app.
   b) Tap the mic icon and command.
   c) HC05 receives the command and forwards it to the Arduino.
   d) Arduino implements the task through relay switches.

ii)   Arduino Control Application:
   a) Connect Bluetooth through the app.

   b) Tap ON/OFF for specific appliance.
   c) The app communicates the specific command to the HC05. Arduino processes and executes the command.
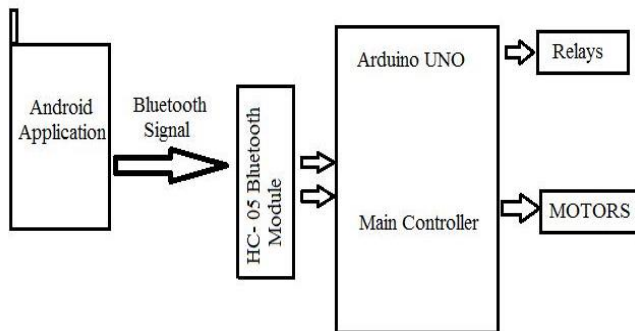

Fig-2: System Architecture

Yash Mittal[3] et.al talks about developing a home automation system using a dedicated hardware module for the voice recognition module and a Arduino Uno microcontroller to send respective commands to devices. The voice commands are divided into five groups with up to seven commands in each group. The command groups are Access, Safety, Fan, Light and Utility. The user has to state the group name followed by the command for it to register successfully.

The voice recognition module is trained using the voices of five male and five female users. This ensures that the system can recognize voice commands irrespective of user age, gender, accent and distance from microphone.

A bar graph of the average number of attempts it takes to successfully recognize a command at different distances from the microphone is generated to determine the best position for placing the central microphone.

The key steps of this implementation are:

   a) Voice Recognition using a dedicated module and a microphone.
   b) Command Interpretation using a voice recognition module and a microcontroller working in unison.
   c) Sending control signals to devices depending on commands.

The Access group is used to open or close doors and uses NFC. The Light and Fan group are used to control the lights and fans throughout the house. The Utility group controls the sprinklers and blinds. The Safety group is used to sound an alarm and silence it.
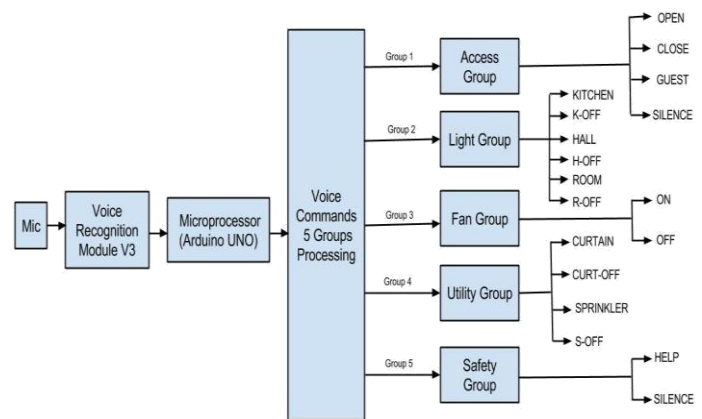

Fig-3: Block Diagram of Prototype System

Mukesh Kumar[4] et.al proposed to make a home automation system specifically for the paraplegic people. The main challenge discussed in this was how to adjust a bed in different positions using voice commands. As the disabled can't afford the hefty price tag of something like Google Home, the system described in this paper used readily available devices like:

   i)   Arduino Uno Micro-controller
   ii)   Relay circuit
   iii)   Wooden Adjustable Bed
   iv)   Electrouse Voice Recognition Module

Home automation systems are mainly seen as a luxury by many but for this particular demography, it is of great help as the physically challenged people become a little bit more independent as they can adjust their bed on their own without assistance from anyone. To keep it cost effective, an Arduino micro-controller is used instead of a PC.
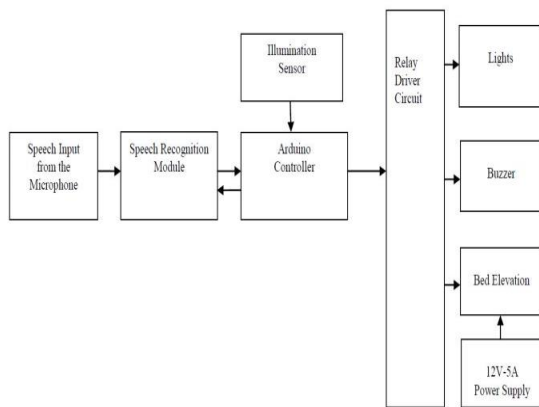
Fig-4: Block diagram of voice recognition based home automation system .

From figure 4 we can see the basic functioning of the system. The speech input is taken via a microphone with a 3.5mm jack. This input is then transported to the voice recognition module which is the Electrouse Voice Recognition Module v3. The voice recognition module cannot be used as it is and has to be trained first. Once it is set up, the speech input is compared with the previously stored samples and then it is passed on to the Arduino for actuation of the command. The module can store up to 80 commands of 1500ms each.

After passing it to the Arduino Uno, the appropriate action is taken and passed via the relay circuits to the necessary devices. The Arduino has instructions in C++ coded using the Arduino IDE. The relay circuits are connected to the lights, the bed and a buzzer.

The light sensor is used to sense whether the room is illuminated enough and necessary action is taken. That is, if there is no proper lighting, the lights are witched on and if there is enough sunlight, then the lights are switched off to conserve energy.

As the system is mainly designed for the physically challenged people, the Arduino is connected to a Buzzer to notify the guardians or anyone taking care of the person for any necessities, etc.

The bed is made out of wood instead of metal as it is easier to lift. A motorized jack is used which requires a power supply of 12V DC and 5A current as shown in the figure. The bed can be adjusted into three positions:

i)   Sleeping position (180-degree w.r.t the ground).
ii)   Resting position (150-degree w.r.t the ground).
iii)   Sitting position (135-degree w.r.t the ground).

The motorised jack and lift a maximum weight of 1500 kg. In the end of the paper, they had discussed the accuracy of the voice commands and their recognition. The conclusion was that the accuracy in silent conditions was 80% and in noisy conditions it was 60%.

3. PERFORMANCE METRICS

Home automation is a new and relatively broad concept which encompasses a wide array of different technologies. To compare how different ways of implementing a single module fare against each other, we need to have well defined performance metrics and a way to measure the same. The performance metrics we have chosen for this assessment are:

1.   Flexibility: A home automation system needs to adapt to different users and their requirements. It needs to be able to recognize voice commands from all users irrespective of their age, gender, accent and pitch. It must also be able to work with appliances the user already owns, so that he doesn't have to purchase additional appliances. The system must have multiple interfaces so that the user can choose whichever is most convenient to him. Interfaces can include a simple voice command interface, a mobile application to control devices or a central hub with all these options.

2.   Robustness: A home automation system needs to be robust i.e. it should work even under less than ideal conditions. The voice recognition module must be able to recognize commands even when the user is at a distance from the microphone [6]. Ambient noise and background disturbances must have minimal impact on performance. Suppose the microphone is placed in a room where both, a noisy fan and a television are turned on and the user wishes to give a command. It wouldn't be viable to expect the user to mute the television every time he wants to give a command, therefore a good home automation system must take all these factors into consideration and find a way around them.

3.   Security: Modern home automation are also used to lock and unlock the doors in a house. It is obvious that if the system isn't designed with a focus on security this could be a major threat to its owners. Also, if the system works on a wireless network, it is imperative to ensure that the channel is secure, before any transmission is sent. A system that is built from the ground up with emphasis on safety of the client is preferable. This metric will also consider systems that provide additional features like intruder detection, smart alerts, secure locks, etc.

4.   Cost: A major factor that decides how successful a home automation system is the cost the user has to incur. A system may have all the latest bells and whistles, but if the user cannot afford it he simply will not buy it. Cost includes but the initial cost of the product as well as the cost of installation and long term maintenance. An automation hub may appear to be cheap but when you consider the cost of all the additional appliances you need to buy along with the hub, the cost adds up. Also, if the system is wired, the cost of labour that is needed for installation needs to be kept in mind.

5. Response Time: Everyone today is used to instantaneous results, therefore in order for a home automation system to be truly useful it must respond to inputs in the shortest time possible. Some algorithms give superior results for command recognition but the time they take for computation is not ideal. An ideal algorithm would be one which strikes a perfect balance between computational power and response time.

4. OBSERVATIONS & ANALYSIS

Table-1: Observations of various methods

Method	Flexibility	Robustness	Security	Cost	Response time
1	The System is trained according to the user therefore it is flexible. This method is highly adaptable to any environment because of low requirements	The Accuracy with a Dedicated microphone is 60% - noisy and 80% - quiet Accuracy without using a dedicated microphone is 30% - noisy and 60% - quite	No security issue Addressed.	Since we are using just 2 PC's and Arduino UNO the cost is minimal	The time taken to execute a command for a distance between 10-15 meters is 145 milliseconds
2	The system is flexible as it uses open source applications from the android play- store thus adding to the Database while learning Commands and referring To files from All over the world.	Robustness depends on OS, company of the mobile and quality. Even after that the system performance is 87% accurate. Noisy environment mildly affects the system.	Secure protocols are used over the internet As it uses google apis.	The need of mobile devices of the user drastically reduces the Hardware cost and only requires basic modules to Make the environment smart. Thus, less costly.	With a Bluetooth range of up to 20 meters, the system performs within 1 to 3 seconds with a good internet connection and maximum 5 seconds with slow internet. Response time is above average.
3	Flexible since voice Recognition module is trained for various demographics. Can adapt to any environment.	Works well even when the user is far away from the microphone. Performs well Under low levels of noise but Performance decreases withhigher levels.	Channel is secured Before transmission Can take place. High security.	Cost is minimal since a single micro-controller and voice recognition module is Used.	Average response time.
4	Flexible as speech module can be trained. Can be applied to any home except for the adjustment of bed part.	Accuracy in silent condition 60%. Accuracy in noisy conditions 80%.	Almost negligible Security	The home automation equipment is very cheap. Cost of wooden bed Not included	Average response time

5. CONCLUSION

In conclusion all four of the methods were cost effective as compared to the market staples like Google Home, and were implementable easily with readily available equipment at home but, the home automation sector is still in its early stages and its popularity is growing by the day. There is a lot of scope in this topic as discussed in all the four papers.

The main challenges faced were speech recognition in noisy conditions, the training of the voice recognition module, number of commands stored in the database of the voice recognition module and the response time or the latency of the module and the device on which the code was embedded. Overall, these creases can be ironed out by researching further and the system can be made quicker and more intuitive.

6. FUTURE SCOPE

With the increasing demand for convenience and entertainment, home automation is just a step away from being the most in demand technology in the near future. We can develop a wireless home automation system that will take voice commands from the user to control various appliances throughout the house. We plan to make our system adapt to the existing appliances of the house rather than buying exclusive appliances that the various existing home automation systems require. The basic objective of this project is making this technology more economical and thus more reachable to the common man. We intend to use

Raspberry Pie 3 for this project which will help in making the system wireless.

REFERENCES

[1]. Sushant Kumar and S.S. Solanki, "Voice and Touch Control Automation", 3rd Int'l Conf. on Recent Advances in Information Technology, 2016

[2]. Aml A. Arriany and Mohamed S.Musbah, "Applying Voice Recognition Technology for Smart Home Networks", IEEE 2016

[3]. Yash Mittal and Sonal Sharma, "A Voice-Controlled Multi-Functional Smart Home Automation System", IEEE Indicon 2015

[4]. Mukesh Kumar, Shimi S.L. ,"Voice Recognition Based Home Automation System for Paralyzed People", International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE) Volume 4, Issue 10, October 2015.

[5]. D. Gann, J. Barlow, and T. Venables, "Digital Futures: making homes smarter". Citeseer, 1999.

[6]. J. Picone, "Fundamentals of speech recognition: A short course," Institute for Signal and Information Processing, Mississippi State University, 1996.

[7]. L. J. Kaila, "Technologies enabling smart homes," Tampereen teknillinen yliopisto Julkaisu-Tampere University of Technology. Publication; 846, 2009.

[8]. P. Rashidi and D. Cook, "Keeping the Resident in the Loop: Adapting the Smart Home to the User," IEEE Transactions on Systems, Man and Cybernetics, Part A: Systems and Humans, vol. 39, no. 5, pp. 949–959, Sep 2009.

[9]. Elechouse, "Arduino library for Elechouse Voice Recognition V3 module," 2013, [Last accessed on 16 Jun 2015]

[10]. Mitali Patil, Ashwini Bedara, Varsha Pacharne, "The Design and Implementation of Voice Controlled Wireless Intelligent Home Automation System based on Zigbee"; Volume 2, Issue 4 April 2013.

[11]. T.Kirankumar and B. Bhavani, "A Sustainable Automated System for Elderly People Using Voice Recognition and Touch Screen Technology International Journal of Science and Research (IJSR), vol. 2, pp. 265-267, August 2013.

[12]. P. Rashidi and D. Cook, "Keeping the Resident in the Loop: Adapting the Smart Home to the User," IEEE Transactions on Systems, Man and Cybernetics, Part A: Systems and Humans, vol. 39, no. 5, pp. 949–959,Sep 2009.