Journal of Scientific Research and Development 3 (1): 33-38, 2016
Available online at www.jsrad.org
ISSN 1115-7569
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Simple speech controlled home automation system using android devices

Theodore Ramli *, Natashia Nabiha Dabimel, Mazlina Mamat, Norfarariyanti Parimon, Rosalyn R. Porle

Artificial Intelligence Research Unit, Faculty of Engineering, University Malaysia Sabah, Kota Kinabalu, Sabah, Malaysia

Abstract: Speech control is an emerging innovative method to accomplish control tasks. In this work, a system is created to control two of the most human interactive activities; switching on and off of lights and fans using ATMEGA-328P microcontroller and Android OS' speech recognition. This system improves the living standard by making life easier and increasing productivity. The development of the prototype will be made within a low budget in hopes to attract people.

Key words: Speech control; Android; Bluetooth; Home automation; Arduino Uno R3

1. Introduction

The society's advancement today towards a digital world is through the contribution of engineers. The advancement has changed the way we live our life in a technology dependent world. Today, we are living in the era where technology is studied to improve our life for the better. One of the studies involves a Voice Activity Detection algorithm (Eshagi and Mollaei, 2010) which was introduced and continued to be developed based on the Wavelet Packet Transform. Speech recognition devices are being explored for various applications in various fields such as medicine (Dubey et al., 2014), rehabilitative devices (Dubey et al., 2014; Kokate and Agarkar, 2014; Prathyusha et al., 2013), home automation (Casimiro, 2014; Khalid et al., 2014; Aripin, and Othman, 2014) and its subsystem (Principi et. al., 2015), mobile robots (Rogowski, 2013; Chhajed et. al., 2013) children tracking system (Navya et. al., 2015) and many more. This allows us to concentrate on other works that have to be done by hand (Dubey et al., 2014). This also allows devices to be controlled by handicapped person with arms or hands impairments (Kokate and Agarkar, 2014), (Prathyusha et al., 2013). Controlling electronic devices by voice is one of the latest technologies being explored by many researches (Dubey et al., 2014).

Day by day, the number of handicapped people is increasing due to road accidents and diseases such as paralysis (Dubey et al., 2014), (Kokate and Agarkar, 2014), (Prathyusha et al., 2013). Based on a report on disability jointly presented by World Health Organization and World Bank, currently there are 70 million people who are disabled (Kokate and Agarkar, 2014) and most of them are physically handicapped (Prathyusha et al., 2013).

Speech recognition is the process of converting spoken words into machine readable format, suitable for processing (Chhajed et al., 2013). The concept of controlling a device by speech was tested with mobile robots (Rogowski, 2013), (Chhajed et al., 2013) through a mechanism to process voice commands in quasi-natural language (Rogowski, 2013). Using near-field and far-field algorithm, a system of microphone arrays was made with the objective towards full spatial control of the robot through spatial voice commands (Gontmacher et al., 2012). Upon receiving voice commands, the processing is conducted by recognizing individual words of the voice command by a Speech Recognition engine (Aripin and Othman, 2014), using grammar rules, syntactic analysis using spread activation algorithm as well as semantic analysis based on procedural semantic network (Rogowski, 2013). These steps will initiate the device to receive instructions and perform action as how it is programmed.

'Home automation' is a word that describes the common home being transformed into 'smart homes' that provides a higher level of security and comfort (Khalid et al., 2014). The application includes turning on the light in a room, the television, the fan and many more (Casimiro, 2014), (Aripin, and Othman, 2014). Speech control gives users a natural feeling in controlling an item, hence the start of incorporating the idea of speech control onto the normal life style of people (Khalid et al., 2014). Home automation system provides an increased standard of living for the employed, elderly and physically impaired population (Dubey et al., 2014), (Khalid et al., 2014).

Based on a research done in Fiji (Khalid et al., 2014), where the research focused more on the South Pacific region, 60% of the participants are making an effort in energy conservation. Upon introduction of a smart home device made for the research, participants show interest towards the

* Corresponding Author.

device but are not willing to install it in their homes due to the cost of the device. Clearly, cost is always an issue but in long term, the device can save up to 81.25% in regards to energy consumption and electricity bills.

Keeping this in mind, an attempt was made to design and develop a simple and cost-effective speech-controlled system that controls the essentials devices at home. Light bulbs are used as the controlled essentials which will be controlled using an ATMEGA328P-PU microcontroller, mainly used on an Arduino Uno R3 development board, an open-source electronics prototyping platform, using Arduino IDE as programming language. The microcontroller will receive commands wirelessly from a device with Android OS (Principi et. al., 2015) via Bluetooth.

2. Methodology

Rapid Application Development (RAD) model was used to develop the system, which provides the ability to shorten construction cycle to build a product. Fig. 1 shows the comparison between traditional and RAD models (Dalisay, 2013). The RAD model that will be used for developing the system is as shown in Fig. 1.

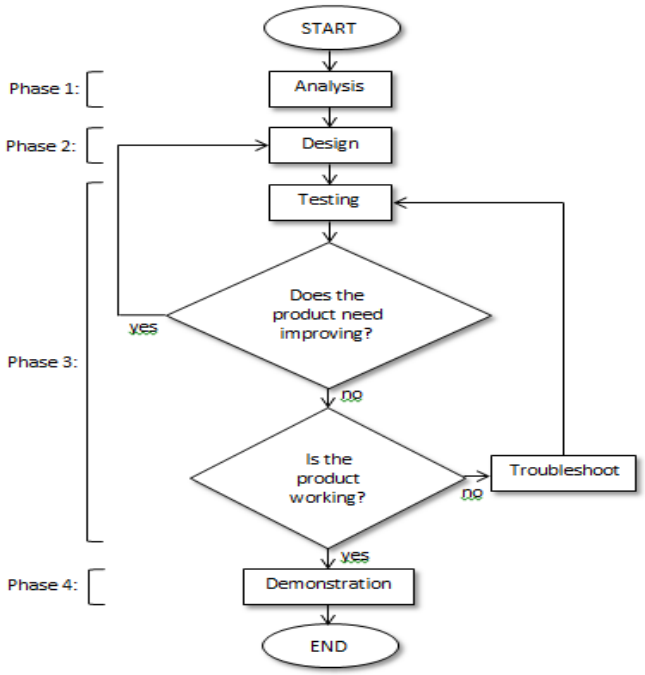

Fig. 1: Methodology implemented for development of the system

There are many advantages of this model. The main advantage is less development time is used. The advantages (RiantSoft LTD, 2013; Wyster, 2008) of RAD model are:

- Reduced development time.
- Increase reusability of components.
- Integration from very beginning solves a lot of integration issues.

However, there are disadvantages of the model. The main disadvantage is this model requires an individual who is experienced and familiar with the system to be developed. The disadvantages (RiantSoft LTD, 2013; Wyster, 2008) of RAD model are:

- Depends on strong team and individual performances for identifying requirements of the system.
- Only systems that are modular can be built using this model.
- Requires highly skilled developers/designers.
- High dependency on modeling skills.
- Team may be tempted to rush the product, skipping important planning and design consideration.

The development process is divided into 4 phases. Phase 1, which is the Analysis phase, involves data gathering. Data was collected from Arduino website (www.arduino.cc) on the procedure to program the microcontroller used for the system being developed. Other than that, a website called Instructables (www.instructables.com) was also used to search for available system with the search term "Arduino", "Bluetooth" and "Android" (Casimiro, 2014), improve the system.

2.1. Hardware design

Initial design from Instructables (Casimiro, 2014) shows a system controlling LEDs using an Android smartphone via Bluetooth. The system's hardware was improved so that it can control electrical devices such as light and fan. The improved system is as shown in Fig. 2, where there is an addition of a 2 relay module, battery representing power source, motor and LED to represent electrical devices controlled by the system, and voltage divider from the TX pin of Arduino Uno R3 to the RX pin of the Bluetooth module HC-06. Fig. 2 was created using open-source software called Fritzing (www.fritzing.org) where it enables users to create circuit graphically, in schematic, and in PCB.

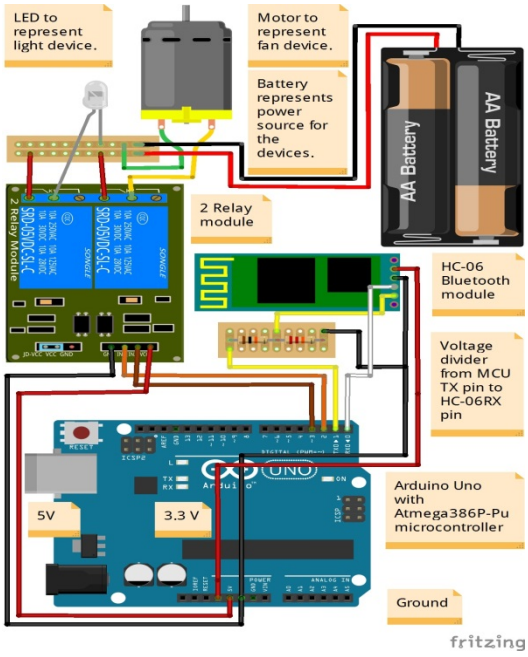

Fig. 2: Circuit developed using Fritzing application

2.2. Software design

The design of software is represented in Fig. 3. The system must be connected to an Android OS smart phone with Bluetooth capabilities to work. The software was designed to be compatible with the Arduino IDE, which uses C language to program. Arduino IDE is chosen because it is an IDE that is well maintained by a community of developers.

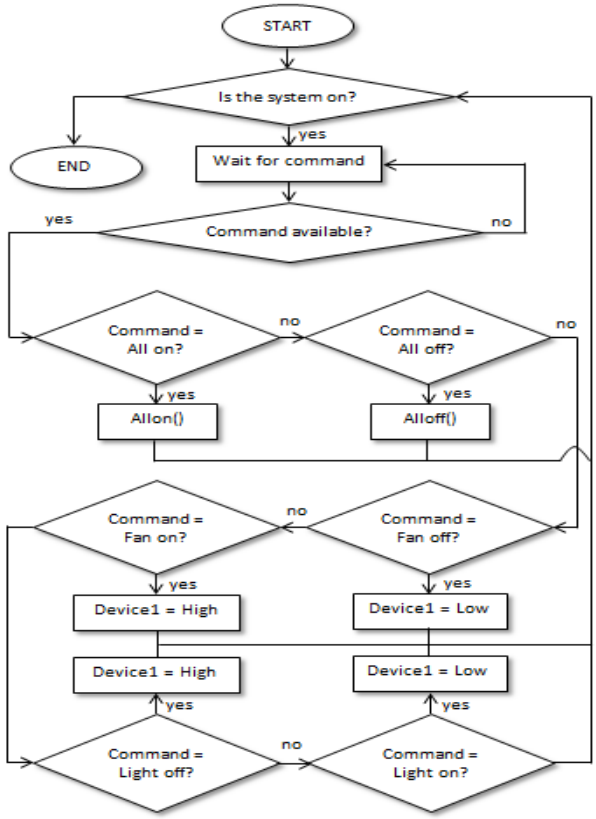

Fig. 3: Flowchart of the system

When a speech command is initiated from the Android OS smart phone, it will analyze the speech and convert it to text. After that the text is sent to the system via Bluetooth. The system will match the text to any commands set within the system. If there is no match, the system will not do anything. However, if there is a match, the system will operate accordingly.

Implementation of the speech command is as shown in Table 1. As can be seen in the table, each action is set to its respective commands. The commands were made as simple as possible to enable users to understand how to use the system in a short amount of time.

Table 1 also represents the initial design of the system's command input. This set of command is further improved, as shown in Table 2.

2.3. Hardware implementation

Hardware is the most sensitive component of this project, because any wrong connection of hardware components will cause the project to malfunction.

Table 1: Commands of the system

Action	Command
Switch on device 1 (fan)	Fan on
Switch off device 1 (fan)	Fan off
Switch on device 2 (light)	Light on
Switch off device 2 (light)	Light off
Switch on both devices	All on
Switch off both devices	All off

The hardware implemented is as shown in Fig. 4. By using Arduino Uno R3 development board as seen in Fig. 4a, error percentage is reduced significantly.

Fig. 4b shows the 2 relay module which is solder on top of a strip board. This was made so this module can be plugged directly on top of the Arduino Uno R3, as shown in Fig. 5.

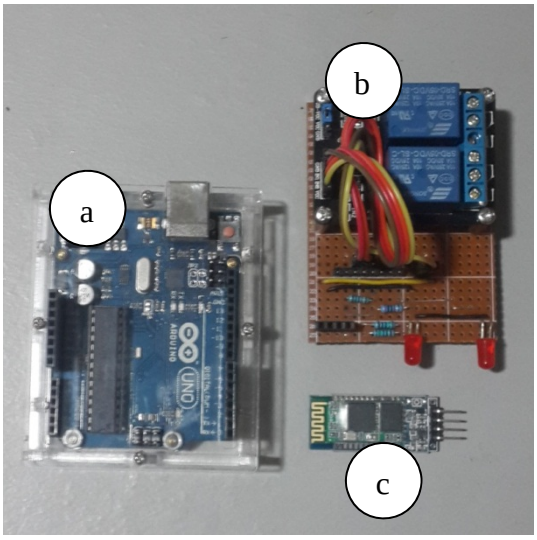

Fig. 4: a) Arduino Uno R3. b) Relay module. c) Bluetooth module.

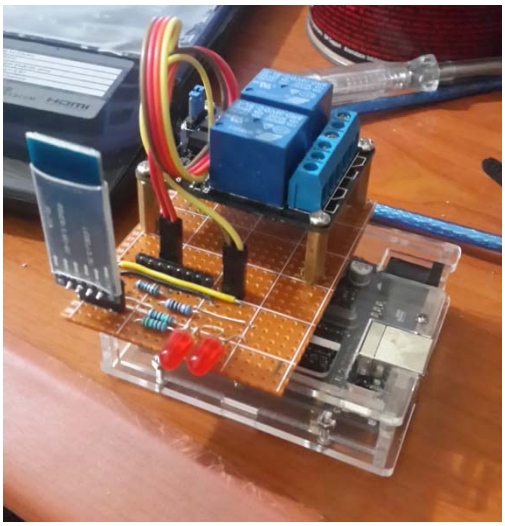

Fig. 5: Completed hardware implementation

Next, the Bluetooth module, as seen in Fig. 4c, is used to communicate between an Android OS smart phone and the system. The model of the Bluetooth module is HC-06.

The reason for soldering the relay model on top of the Arduino Uno R3 development board is to reduce the size of the prototype, and to tidy the circuit from wires. Initially the size of the prototype

with a breadboard was 4 times larger compared to the final prototype, as seen in Fig. 5.

2.4. Software implementation

The Arduino IDE is based on C language programming. The source code size is 109 lines.

2.5. Prototype testing

After software implementation, everything is connected as seen in Fig. 6 and Fig. 7.

A switch for wall mount was used to as switches for the system, the fan, and the light. The power source of this system is 6 pieces of AA batteries. This gives a 9 volt source to the system and the fan. 4.5 volt was also taken from the arrangement of batteries to power the light.

Fig. 6: The completed prototype, with switch, fan and light

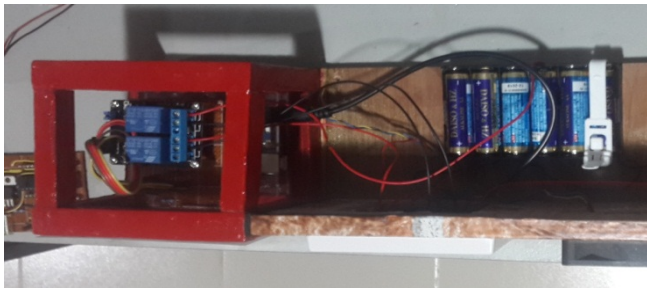

Fig. 7: Top view of the prototype. Battery as power source for all devices

The operation of the system is shown from Fig. 8 to Fig. 10. As seen in Fig. 8, the fan and light operates normally when the system is switched off. When the system is switched on, the system will switch off both the fan and light, as seen in Fig. 9. The electrical devices are now controlled by the system. When the command "All On" is initiated through the Android OS application, the system will switch on both electrical devices as seen in Fig. 10.

Fig. 8: Normal application without the system being switched on

Fig. 9: When system is switched on, everything operates through the system

Fig. 10: When "All On" command is initiated, all devices are switched on

The Android OS application is shown in Fig. 11. To initiate a speech command, the button in Fig. 11b has to be pressed. When speech is received, the application will convert it to text, and send the text to the system.

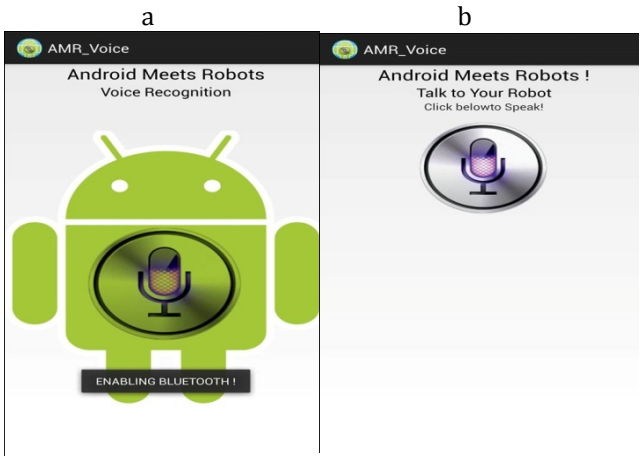

Fig. 11: a) Android application starts up. b) Interface when connected to system

2.6. Troubleshooting

There was not much problem observed during development. However, commands involving the word "fan" give some problem since it has a close resemblance to the word "fen" and "fend". The word "off" also has a resemblance to the word "of". If the command "Fan Off" is said too fast, the system will detect it as "fanoff". The accuracy for all commands except for fan-related commands is 100% accurate. For fan-related commands, the accuracy is 66.67%. The solution for this is to implement extra commands that will do the same action. This is shown in Table 2. The system was able to capture the local language of the word "fan" and "light", which is "kipas" and "lampu" respectively. This set of speech command give 100% accuracy. This set of command would also give the advantage to market this product to locals in Malaysia in the near future. "All on" and "All off" command is also simplified to

"On" and "Off" command to simplify the speech command processing.

Table 2: Extra commands of the system

Action	Command
Switch on device 1 (fan)	Fan on
	Kipas on
Switch off device 1 (fan)	Fan off
	Kipas off
Switch on device 2 (light)	Light on
	Lampu on
Switch off device 2 (light)	Light off
	Lampu off
Switch on both devices	All on
	On
Switch off both devices	All off
	Off

A. Prototype Cost: The total cost for developing the system is as shown in Table 3, assuming that users have an Android smartphone with Bluetooth capability. A whole system which would include an Android smartphone would give an estimated minimum cost of RM300. Cost can be significantly reduced if the product is assembled in a great amount and factory fabricated.

B. Survey: A survey was made with 20 participants. The survey consists of two parts where as shown in Table 4 and Table 5, the first part asks about the participant's background and technology preference, and in Table 6, the second part evaluates the system's performance and recommendation.

3. Result

Table 3: List of components

Component	Quantity	Unit Price	Total Unit Price
Arduino Uno R3	1	RM 42.00	RM 42.00
HC-06 Bluetooth module	1	RM 20.00	RM 20.00
9V power adapter	1	RM 16.00	RM 16.00
2 Relay Module	1	RM 10.00	RM 10.00
LED	2	RM 0.30	RM 0.90
Logistics	1	RM 10.00	RM 10.00
	Total		RM 98.90

Table 4 shows the participants' background. The majority age of participants is within the age of 21 years old to 40 years old. 70% of participants are familiar with technology and spend a minimum average of 5.2 hours on their phone.

Table 4: Participant background

Age Range	21-30	31-40	41-50	51-60
Number of Participants	8	8	2	2
Technology Familiar Participants	8	4	1	1
Average use of phone daily	Minimum 4 hours	Minimum 6 hours	Minimum 6 hours	Minimum 6 hours

Table 5 shows what participants look for when purchasing an electrical/electronic device. Most participants don't mind the price of a technology, as long as it is useful and is high in quality.

Table 5: Technology criteria

Technology Criteria of Choice	Participants	Percentage
Price	2	10%
Quality	9	45%
Usability	9	45%

Next, the system's performance and recommendation are evaluated in the second part of the survey. Table 6 shows the score of each criterion, in percentage. Based on Table 6, the system is preferable, but many participants would prefer the system be integrated with a button application to be useful in their daily lives. For participants age 41 and above, they require support from a technical person to use the system, since most of them are not technology literate.

4. Conclusion

In this development and study, it focuses on helping those with disabilities, bed-ridden patients and elderly, by using Android OS devices to detect speech command.

This can help them to control devices such as lights and fan, and provide an alternative method to control the devices through speech without having to handle a switch manually, hence, serving them in accomplishing their daily life routines like a normal person.

Although this development and study focuses on a speech recognition-based system interface, more advancement and improvement can be made through more study.

One such improvement would be to fully integrate the Android OS with the Android system, which will make the system a standalone version and would fully operate without the use of a button to detect voice.

This system can be modified to be used on other focus group, where the system can be interface with an Android application with button.

The efficiency of the voice command control system can be further improved by implementing neural based algorithm.

Table 6: System analysis and recommendation

Description	Score
Like the system	87.0%
System is complex	53.4%
System is easy to use	80.0%
Need support from technical person to use the system	40.0%
The system is well integrated	73.4%
Too much inconsistency in the system	53.4%
The system can be learned quickly	93.4%
The software is hard to use	33.4%
Felt confident using the system	86.6%
Need to learn more before using the system	33.4%
Average price willing to pay	RM100
Preference between voice and button application	90% button 10% voice
System recommended to	30% bedridden patients 40% disabled individuals 30% elders
Helpfulness of the system in daily lives	30% not helpful 70% helpful

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