VOICE CONTROLLED MOBILE EMBEDDED DEVICE

BY

CHONG YI XUAN

A REPORT

SUBMITTED TO

Universiti Tunku Abdul Rahman

in partial fulfillment of the requirements

for the degree of

BACHELOR OF INFORMATION TECHNOLOGY (HONOURS)

COMMUNICATIONS AND NETWORKING

Faculty of Information and Communication Technology
(Kampar Campus)

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Date: 18/9/2020

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I declare that this report entitled "**VOICE CONTROLLED MOBILE EMBEDDED DEVICE**" is my own work except as cited in the references. The report has not been accepted for any degree and is not being submitted concurrently in candidature for any degree or other award.

Signature : 

Name : Chong Yi Xuan

Date : 17 September 2020

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ABSTRACT

This project is a voice-controlled robot project for academic purpose. It will provide readers with the introduction, literature review, system methodology and system design. The robot in this project will be called as Alexabot, and it is an Alexa based voice-controlled robot. This robot is built-up by using GoPiGo, Raspberry Pi, speaker and USB microphone dongle. Amazon's Alexa voice service will be implemented into the Raspberry Pi so that the robot will be able to use the AlexaPi service. This report will also review the current technologies, such as hardware platform, firmware/OS, database, programming language and algorithm. Besides, this project will also implement third party services which are ngrok and Flask into the robot. Other than that, this project will also contain a few functional modules which are voice recognition module, online searching module and robot movement module.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ASK	Alexa Skills Kit
CPU	Central Processing Unit
LAN	Local Area Network
SAPI	Speech Application Programming Interface
URL	Uniform Resource Locator

Chapter 1

Introduction

1.1 Motivation and Problem Statement

According to Finch (Finch, n.d.), there are several problems towards voice recognition which are lack of accuracy and misinterpretation, accents and speech recognition and background noise interference. As Zhou, Blackley, Kowalski, Doan, Acker, Landman, Kontrient, Mack, Meteer, Bates and Gross state that the error rate of clinical notes generated by speech recognition software among 217 clinical notes randomly selected from 2 health care organizations was 7.4% (2018, p.e180530). This is most likely because of the speech recognition software will not always show the commands given by command giver on the screen completely accurately (Finch, n.d.). Besides that, Finch also state that the speech recognition software can only interpret the meaning of commands after decoded it from analog signal to digital signal (Finch, n.d.). Homonym, slang, technical words and acronyms are the obstacles those will cause the speech recognition software misinterpret the meaning of words given by human.

The next major problem would be the accents and speech recognition. As people know, Japanese English has a very heavy accent. For example, the words ‘shop’ will be pronounced as ‘shoppu’ in Japanese English. This kind of pronunciation is very difficult for the speech recognition software to differentiate whether it is a British English word or Japanese English word. Besides that, Finch said that when the voice of command giver is changed due to cold, cough, sinus or throat problem, the speech recognition software may be having problems to recognize voice as normal (Finch, n.d.).

The third problem is background noise interference towards speech recognition. A speech recognition software may have problems differentiating the speech of command giver from the ambient noise and other people talking because multiple source of voice will lead to mix-ups of transcription and errors (Finch, n.d.). So, use of speech recognition software in an open venue with a lot of background noise will reduce the accurately of the speech recognition.

From this proposal, an Alexa based voice-controlled robot that allowed user to give commands by using speech to perform specific tasks such as moving forward, backward, turn left and right will be developed.

1.2 Project Objectives

1. To develop a voice-controlled robot to receive commands given by user using speech.
2. To integrate Amazon's Alexa service into the voice-controlled robot.
3. To craft the Alexa Skills sets to handle different commands given by user using Alexa Skill Kit.
4. To implement this Alexa based voice-controlled robot to move forward, backward and turn left, right.

1.3 Project Scope

In this project, an Alexa based voice-controlled robot that can responds to voice commands given by command giver will be created. The robot will be called as Alexabot. Alexabot is a robot build up by GoPiGo3 and Raspberry Pi with Alexa voice service which is AlexaPi service implemented. By connecting to the network, the robot will be able to perform the actions required by the command giver. For example, when the command giver says "Alexa, forward", the AlexaPi service in the Alexabot will send the speech to the Alexa cloud to process the speech. After the speech is processed, the Alexa Cloud will generate a request with the user intent in json format and sent it to the lambda function in Alexa Skills library. The lambda function in Alexa Skills library will process the request with the respective intent and make web request to the Alexabot flask server according to the user intent. After that, the flask server will handle the web request and execute the forward function. Finally, the Alexabot will be able to move forward.

Besides that, when the commands giver is asking question to the Alexabot, it will answer the question by searching and collecting data from the Internet. For instance, when

the command giver is asking “Alexa, how many cases of corona virus in Malaysia?”, Alexabot will answers the question after searching and collecting data from Internet.

Furthermore, an Alexa Skills library for Alexabot will be crafted by using Alexa Skills Kit. This actions library will be able to adapt and recognize a series of actions with specific value indicators. For example, the command giver can give a command, “Alexa, move forward for 5 seconds.”, the Alexabot will move forward for 5 seconds.

1.4 Main Contributions from the Project

This project develop an Alexa based voice-controlled robot with AlexaPi service integrated, Alexabot, which capable of moving to different direction by following the command given by command giver using speech. Due to the Alexabot capable of performing actions by using voice command, it will be a platform for other developer to integrate other functions and hardware into the robot such as robotic arm. Besides that, getting online information through Alexabot by using speech will be much easier compared to traditional ways which is searching online with the help of keyboard and mouse as input devices.

1.5 Organisation of the Report

This project report is organised by 7 chapters. Chapter 1 provides an overview of the current problem statement of the voice-controlled robot and the motivation. It also provides the project objectives and project scope of the project as well as the main contributions from the project.

In Chapter 2, a review of technologies towards the voice-controlled robot is provided, such as hardware platform, firmware/OS, database, programming language and algorithm. Besides that, review and summary of the existing voice-controlled robot will also be provided in this chapter.

In Chapter 3, some system development models details are provided as well as the selected system development model. Besides that, this chapter will also cover the system requirement and functional requirement. Moreover, project milestone and estimated cost will also be included.

In Chapter 4, system architecture, functional modules in the system and system flow will be included.

In Chapter 5, all the hardware setup and software setup will be included. Besides that, it also provides the setting and configuration procedure to setting up the Alexabot. Moreover, system operation with screenshot will also be covered in this chapter.

In Chapter 6, system testing, and performance metrics will be covered. Besides that, the testing setup and the testing result will be shown in this chapter. Other than this, challenges facing in this project will also be recorded in this chapter. Besides that, an objectives evaluation will be included in this chapter.

In Chapter 7, conclusion and recommendation will be covered.

Chapter 2

Literature Review

2.1 Review of the Technologies

2.1.1 Hardware Platform

Before developing a robotic project, people always looking for a budget hardware. When it comes to budget hardware for robotic development, Arduino and Raspberry Pi are the first two hardware platform that come to mind.

Arduino, a single-board microcontroller board that are equipped with multiple sets of analog and digital I/O pins that can be used to interface with breadboard or other sensors. There is a USB interface on the board, which is used for loading programs from computer to the microcontrollers. To program the microcontrollers, C and C++ programming languages can be used as well as Python when the developer wishes to deal with sensors. Arduino can only run one program in a single instance over and over again.

Raspberry Pi, a single-board computer that are equipped with 40-pin of GPIO pins that can be used to interface with breadboard or other sensors. There are 4 USB interfaces, 1 Ethernet port, 1 HDMI port and a 3.5mm audio jack on the Raspberry Pi. Besides that, it also on-board Bluetooth and 802.11n WI-FI. The programs executed on the Raspberry Pi can be programmed using Python, C, C++, Java, Ruby and Scratch. Raspberry Pi is operated under Linux operating system such as Raspian, DexterOS, etc. Naturally, Raspberry Pi is multi-functional, basically mean it allows running multiple programs simultaneously in a single instance.

2.1.2 Firmware/OS

Operating system is a program with the function of controlling the execution of all the programs and an interface between hardware and applications. The main objectives of an operating system are efficiency, convenience and ability to evolve. Operating system has two roles which are resource manager and control program. As a resource manager, it manages all the software resources and computer hardware and decides between fair resource use and conflicting requests for efficient in computer. Moreover, as a control

program, it prevents improper use of the computer and errors by controlling the execution of the programs and also protect the system from any malicious programs.

Furthermore, operating system can be categorized into 7 types which are single-tasking and multi-tasking, single-user and multi-user, distributed, templated, embedded, real-time and library. First, single-tasking operating system is a system that can only executes one program in a single instance, while a multi-tasking operating system can execute multiple programs concurrency. To achieve the concurrency, the processes use the divided available processor time by time-sharing. The task-scheduling subsystem of the operating system will interrupt each of these processes in time slices repeatedly.

Second, single-user operating system is a system which allow multiple programs to run in tandem without facilities to distinguish the users, while multi-user operating system is a system extends from multi-tasking operating system's basic concept with the facilities to distinguish the users. For example, multi-user operating system will identify which processes and resources are belonging to which users.

Third, distributed operating system is a system that has the ability to manage a group of distinct computers into a single computer. Each of the individual computer node in the distributed operating system will holds a specific global aggregate operating system's software subset. Fourth, templated refers to creating a guest operating system using a single virtual machine image for multiple running virtual machines.

Fifth, embedded operating system is a system that is designed for embedded devices with less autonomy. It is a resource-efficient and reliable operating system that suitable for any hardware with limited resources such as RAM and ROM. For example, raspberry Pi and Arduino are best suited for embedded operating system.

Sixth, real-time operating system is a system that designed for processing data and events without any buffer delays. A real-time operating system can be a single-tasking or multi-tasking operating system. Seventh, library operating system is in a form of libraries that provides typical operating system such as networking. This operating system composed with the configuration code and application to construct a unikernel.

2.1.3 Database

Database is a structured set of data or an organized collection of data that can be stored in cloud, server or personal computer. It can be accessed from a computer system electronically. Databases are often developed using modelling techniques and formal design. Besides that, database can be categorized into 11 types which are centrelised database, distributed database, personal database, end-user database, commercial database, NoSQL database, operational database, relational database, cloud database, object-oriented database and graph database.

First, centrelised database is a database that all the data is stored at a centrelised location. This database can be accessed by users remotely from different locations with the help of application procedures contained by the database. The advantage of this type of database is the data is easier to organize and maintain due to the data is kept in same location, while the disadvantage of this type of database is it may face bottleneck due to high traffic.

Second, distributed database is a database that has the opposite concept of the centrelised database. The concept of this type of database is the data are stored in different locations. Distributed database can be categorized into 2 types which are homogenous and heterogeneous. Homogenous distributed database is the databases which are using same hardware, operating system and application procedures, while the heterogeneous distributed database is the databases which the hardware, operating system and application procedures can be different. The advantage of this type of database is the performance will not be affected with single-site failure of any database. The disadvantage is distributed environment need to be supported by the operating system.

Third, personal database is a database consist of collected data that store on personal computers. The data in this database are often accessed by a small group of users. The advantage of this type of database is easy to manage due to its small size, while the disadvantage is it is not suitable in database expansion.

Fourth, end user database is a database that does not concerns about the transactions and operations but only concerns on product which may be an application or a computer

software. This type of database is specifically designed for end user to use. The advantage of this type of database is it improved in data sharing.

Fifth, commercial database is a paid version of large databases that specifically designated for users who want to access the database for commercial use. This type of database can only be accessed through commercial links provided by the provider. The disadvantage of this database is it cannot afford huge information due to it subject specific.

Sixth, NoSQL database is a database that are used for huge sets of distributed data and information. This type of database is designated to analyze huge size of unstructured data that may be stored in different servers. The advantage of NoSQL database is it able to handle any kind of large volumes of unstructured, semi-structured, and structured data and information, while the disadvantage of this type of database is it is not compatible with SQL.

Seventh, operational database is a database with data related to operations of an organization stored in it. This type of database is designated for users to perform CRUD to the data in real-time. The advantage of operational database is the data are up to date, while the disadvantage of this type of database is initial training is required due to the learning curve is large.

Eighth, relational database is a database categorized by a set of tables. The data are inserted into table based on pre-defined category. The tables in the relational database consist of columns and rows. The columns represent the attribute, while the rows represent the record. The advantage of relational database is it is easy to understand due to it organized tables, while the disadvantage is it may encounter difficulty when the users try to insert data into a current existed table.

Ninth, cloud database is a database that all the data are stored in the cloud which is also known as a virtual environment. The virtual environment can either be a private cloud, public cloud or a hybrid cloud. The advantage is security due to the cloud company their own advanced techniques to secure the database, while the disadvantage is the cloud database may be costly.

Eleventh, object-oriented database is a database consists of a collection of relational database and object-oriented programming. This type of database is organized data in

object. The advantage of object-oriented database is it enriched modelling capabilities due to the data objects are encapsulated in a more natural and realistic real-world objects. The disadvantage of this type of database is lack of standards due to it do not have any standardized model to follow.

Last, graph database is a database consists of nodes and edges. The nodes in the graph database represent the entity, while the edges represent the relationship between the entities. The advantage of graph database is the performance due to each of the vertex will only maintains its neighbor vertex information, so unrelated vertex will not be go through when a query is executed.

2.1.4 Programming Language

Programming language is any of various languages that comprises or expresses a set of detailed instructions that will produce various kinds of output for digital computer use. Programming language can be categorized into 3 categories which are machine languages, assembly languages and high-level languages.

Machine languages are the native language for computer which consist of low-level machine instructions. This is the only language that the hardware will understand. Each of the unique computer will has its own unique machine language. A machine language often represented using binary or hexadecimal. Besides that, each of the instructions will cause the CPU to perform specific task such as load, store and jump. Nevertheless, programming in machine language will be difficult for human programmers due to the machine language need to be memorized in binary code or hexadecimal code.

Assembly languages are the encoded version of machine code where it is more readable for human programmers. Each of the instructions in machine language program will be replaced with simple abbreviations such as ADD, MOV and LW. The assembly language will also unique for each computer. Before execution, the assembly language need to be translated into machine language in order to let computer to understand. The translation from assembly language to machine language will be done by a computer program known as Assembler.

High level languages are the programming languages that are widely used by most of the programmers. This type of programming languages are usually constraints and abstracted the need of a specific machine. The high-level language program can be executed for any machine as long as the machine support the same programming language with the high-level language program. Same as assembly language, high level language is also need to be translated into machine language before execution. To translate the high-level language to machine language, a compiler or an interpreter is used.

2.1.5 Algorithm

Algorithm is a set of rules or a process that need to be followed in calculations or any other problem-solving operations. For speech recognition, there are 2 important parts need to be take care of which are acoustic modelling and language modelling.

The algorithm used in speech recognition is Hidden Markov models (HMMs) which is a statistical Markov model that will output a sequence of quantities or symbols. Nowadays, most of the modern general-purpose speech recognition systems are developed based on HMMs. The reason of using HMMs on speech recognition is because of the speech signal can be read in a short-time stationary signal or a piecewise stationary signal. So, a speech signal can be treated as a stationary process when it is in a short time scale.

Besides that, Dynamic time warping (DTW) is also used as the algorithm in speech recognition. DTW is an algorithm that take in 2 temporal sequences, which are different in speed or speed and measuring for the similarity between them. This algorithm is used for speech recognition before the displacement to HMMs.

2.1.6 Summary of the Technologies Review

In conclusion, to build a robot project, the first concern must be what are the tasks that robot needs to perform. If the robot needs to perform multiple tasks, Raspberry Pi is the most suitable hardware platform. Whereas, Arduino is the most suitable hardware platform if the robot needs to perform only one task continuously. In addition, the second concern would be the operating system. The operating system for the robot must be less power consumption, less RAM and ROM require. For this situation, the embedded operating

system is the best suitable for developing a robot project. Besides that, databases are also one of the concerns because different type of databases is designated for different kinds of usage. Moreover, programming languages will be the next concern for robot project development. High level programming languages are best suitable for robot project due to its characteristic which is easy to understand by human programmers. Last but not least, HMMs is the most suitable algorithm for speech recognition system due to the form of speech signal is able to be treated as the stationary process to be processed by HMMs.

2.2 Review of the Existing Systems/Application

2.2.1 The VoiceBot: A Voice Controlled Robot Arm

In this journal, the authors introduced a speech controlled robotic arm, VoiceBot, and the VoiceBot was implemented by using a system called Vocal Joystick interference engine (House, Malkin and Bilmes, 2009). The Vocal Joystick can provide a unique voice-controlled interface because it is relying on the human vocal tract's enormous flexibility to produce a range of continuous and discrete sounds.

Besides that, The Vocal Joystick do not require any invasive or specialized hardware but only a computer, standard microphone and sound card. The possible application for the Vocal Joystick almost unlimited due to the portable library of the core engine can be used by any application to provide parameters of control.

According to (Bilmes et al., 2005), the Vocal Joystick has three main characteristics which are continuous control parameters, discrete vocal commands and reusable infrastructure. These characteristics of Vocal Joystick help the individuals with motor impairments to use their vocal parameters for continuous control task.

In addition, Vocal Joystick is able to track non-speech vocal properties such as pitch, volume and vowel quality continuously (SOLEYMANI et al., 2009). According to (House, Malkin and Bilmes, 2009), the limitation of the VoiceBot is pitch tracking, because of the pitch response was based on a linear frequency mapping and using linear frequency to calculate the pitch changes, so, in lower frequencies, the effective resolution of the pitch control of the arm will be reduced. This problem can be resolved by using Log-scale

frequency which is much closer to the human perception of pitch (House, Malkin and Bilmes, 2009). Figure 2.1 shows the image of VoiceBot.

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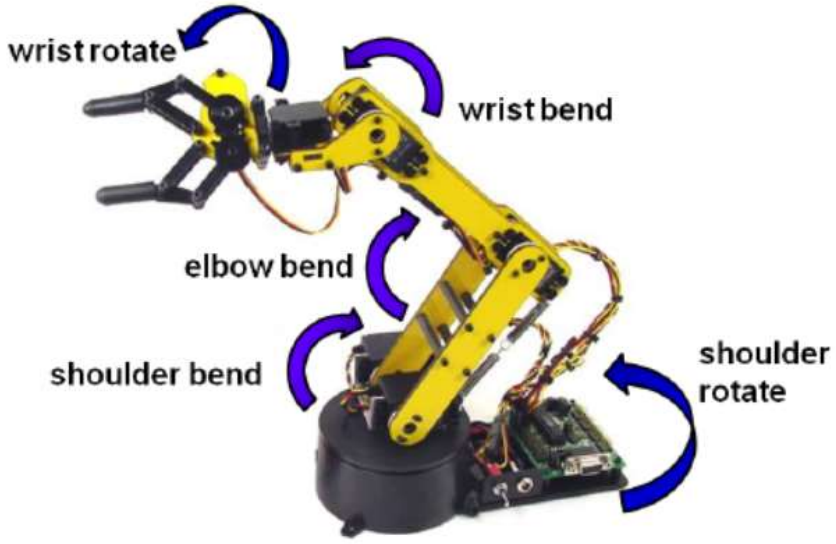

Figure 2.1: Image of VoiceBot (House, Malkin and Bilmes, 2009)

2.2.2 Robot-by-voice: Experiments on commanding an industrial robot using human voice

In this journal, the authors stated that it is possible to reduce tremendously of the noise effect by adding a short command structure with a specific word such as 'Robot' as pre-command string (Norberto Pires, 2005).

Besides that, Norberto (2005, pp.505-511) also stated that the way Automatic Speech Recognition recognizes the speech from the command giver defined by grammars, so the grammar builder methods included in the Microsoft Speech API (SAPI) were used in the project to programmatically construct and modify the grammar.

In addition, if there were multiple robots in the network, the user has to identify the robot first before sending any command by using the sequence of words constitute level rules (Norberto Pires, 2005). In order to overcome this problem, 'Robot' is used as the "TopLevelRule" to let the robot know the user is talking to the robot and a number is spoke

after the 'Robot' as the "SecondLevelRule" to let the robot know which robot is called by the command giver (Norberto Pires, 2005). Figure 2.2 shows the grammar implemented.

TopLevelRule = "Robot"	pre-command word
Rule 0 = "one hello"	check if robot is there
Rule 1 = "one initialize"	ask robot to initialize (open client)
Rule 2 = "one master"	rule defining username "master"
Rule 3 = "one masterxyz"	password of username "master"
Rule 4 = "one open"	open the gripper
Rule 5 = "one close"	close the gripper
Rule 6 = "one motor on"	put robot in run state
Rule 7 = "one motor off"	put robot stand-by state
Rule 8 = "one program run"	start program
Rule 9 = "one program stopt"	stop program
Rule 10 = "one approach origin"	call service 94
Rule 11 = "one approach final"	call service 93
Rule 12 = "one origin"	call service 91
Rule 13 = "one final"	call service 92
Rule 14 = "one home"	call service 90
Rule 14 = "one terminate"	release robot access (close client)

Figure 2.2: The grammar implemented (Norberto Pires, 2005).

Other than that, Norberto Pires (2005, pp.505-511) also stated that safety is also need to be considered. In the project (Norberto Pires, 2005), after each of the robot responds to a specific command such as 'Initialize', the robot will ask for username and password by using voice identification in order to be able to give the command giver the proper access rights. Figure 2.3 shows the sample of communication between command giver and the robot.

User: Robot one hello.
Robot: I am listening my friend.
User: Robot one initialize.
Robot: You need to identify to access my functions.
Robot: Your username please?
User: Robot one <username>.
Robot: Correct.
Robot: Your password please?
User: Robot one <password>.
Robot: Correct.
Robot: Welcome again <username>. I am robot one. Long time no see.

Sequence of commands here. Robot is under user control.

Figure 2.3: The communication between User and Robot (Norberto Pires, 2005).

2.2.3 Arduino Based Voice Controlled Robot

In this journal, the authors build an Arduino based voice controlled robot and stated that the function of speech recognition and central processing unit (CPU) are separated independently (Kannan and Selvakumar, 2015). This is because when CPU distributes its processing power to do speech recognition, the performance of CPU will be decreased. By separate the speech recognition circuit and the CPU, the CPU will merely check if a command has been issued to the robot occasionally by polling the speech circuit's recognition lines (Kannan and Selvakumar, 2015).

In addition, this can even improve by connecting one of the robot's CPU interrupt lines with the recognition line (Kannan and Selvakumar, 2015). This is because when a recognized word was spoken by the command giver, it will cause an interrupt to let the CPU know, so, it will reduce the chance of CPU overhead when CPU do not have to poll speech circuit's recognition lines occasionally (Kannan and Selvakumar, 2015).

Besides that, by using stand-alone speech recognition circuit will promise the programmability so that the programmer who program the speech recognition circuit can train it to recognize the specified words that the programmer wants recognized (Kannan and Selvakumar, 2015).

There are several limitation or weaknesses towards the robot. The first limitation or weakness is when there is noise or other sound around the robot, the error rate will increase (Kannan and Selvakumar, 2015). The second limitation or weakness is the distance between the command giver and the microphone, the greater the distance, the higher the error rate (Kannan and Selvakumar, 2015). Figure 2.4 shows the image of the Arduino based voice controlled robot.

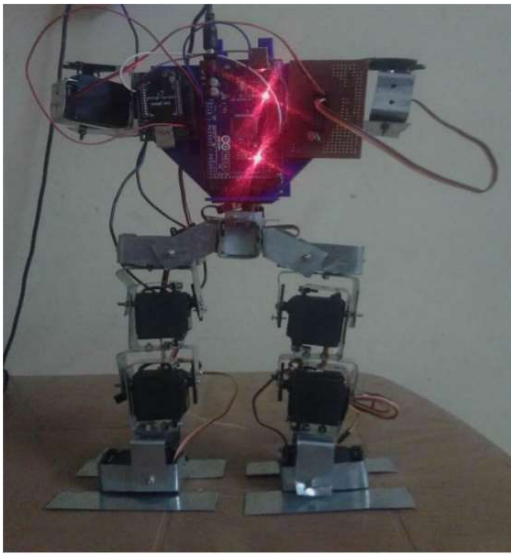

Figure 2.4: Image of Arduino based Voice Controlled Robot (Kannan and Selvakumar, 2015).

2.2.4 Summary of the Existing Systems/Applications

Existing System	Advantages	Disadvantages	Critical Commends
The VoiceBot: A Voice Controlled Robot Arm	A real 5 degrees-of-freedom (DOF) three-dimensional hobbyist robotic arm allows the robot to have high accuracy.	Large amount of set of voice commands are needed to perform a high accuracy task due to the limitation of this system can only control 1 dimension in a single command.	The authors may reconstruct the structure of the voice commands to tackle multiple actions in a single command to reduce the total amount of voice commands to perform a specific and high accuracy task.

Robot-by-voice: Experiments on commanding an industrial robot using human voice	Pre-command word able to reduce the chances of getting response from non-target robot when multiple robots exist at same place.	The system is highly reliable to network connection.	Reduce the dependency of the system to network connection.
Adruino Based Voice Controlled Robot	Less power consumption for CPU due to the independently function of speech-recognition circuit from CPU.	Rate of successfully speech recognition will increase due to environment and distance between human and robot's microphone.	Increase the rate of successfully speech recognition.

Table 2.1: Summary of the Existing Systems

Chapter 3

System Methodology

3.1 System Development Models

3.1.1 Iterative SDLC Model

Iterative model is a model that based on the idea of developing an initial implementation of a part of the system requirements and iteratively improving and evolving the implementation through several versions until an adequate system is implemented, developed and ready to be deployed.

In each of the iterative processes, there are 5 stages will be included which are planning and requirements, analysis and design, implementation, testing and evaluation. The iterative process will be applied after the initial planning phase over and over again until the system is adequate and complete. After that, the iterative process will be ended and enter the final phase which is the deployment stage where the system is going to be deployed.

Besides that, by having the characteristic of the iteration will make the iterative model suitable for a scenario like when there is a new technology is being learnt and is being used by the developers in the development team while project development is already started. Other than this, iterative model also suitable for the industry when there are very high-risk of the system features and goals which may change in the future during the development process.

Moreover, the advantage of the iterative model is the cost of changes in system will be reduced due to the model is applied at the early stage of the development, which makes it less difficult to find any design and functional errors. In addition, the iterative model will also be having the advantage of supports changing environments due to the changes can be applied in future iterative process.

Nevertheless, the disadvantage of the iterative model is it is not suitable for any smaller projects. This is because it may require more resources during the iterative process. Figure 3.1 shows the image of Iterative SDLC model.

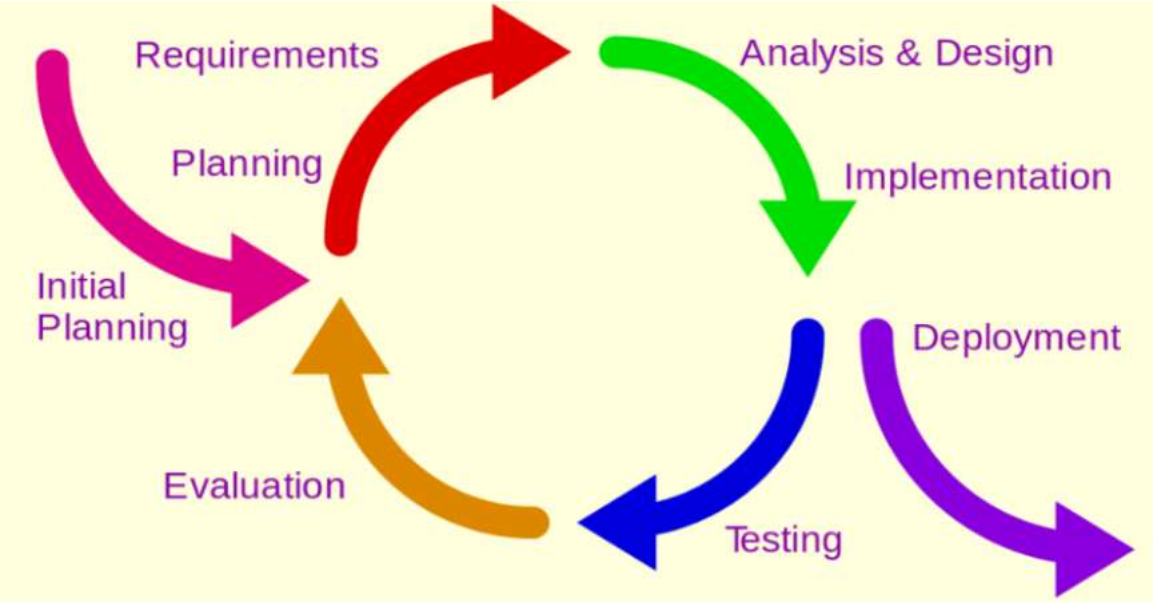

Figure 3.1: Image of Iterative SDLC Model (Panagoulias & Anastasios, 2017)

3.1.2 Agile SDLC Model

Agile model is a model that the system will be developed into a series of versions where each of the versions will be involved with client for version evaluation and specification during the development process. Each of the system versions is incremental with additional features until the final version of the system which consists of all the require features from the client.

In each of the iteration process will be involved planning, requirements analysis, design, coding, unit testing and acceptance testing. After each of the iteration process, a version of the system will be developed and released to the client and collect the feedback from the client after the system is used by the client.

Agile model is suitable in a scenario when the clients want to involve themselves into the system development and wish to interact with the developers to discuss about the system features. Besides that, the agile model is also suitable when always have new changes need to be implemented into the system.

Moreover, there are several advantages of applying the agile model. The first advantage is any of the unstable requirements from the future will not hold up the system

development progress. The second advantage is the client will be able to see the on-time delivery of increment and have a better understanding on what is the progress of the system development.

Nevertheless, one of the characteristic of the agile model is that it required only little formal documentation. By having this characteristic, problems may arise when the original developers are resigned or the project is handle by other development team during the maintenance stage.

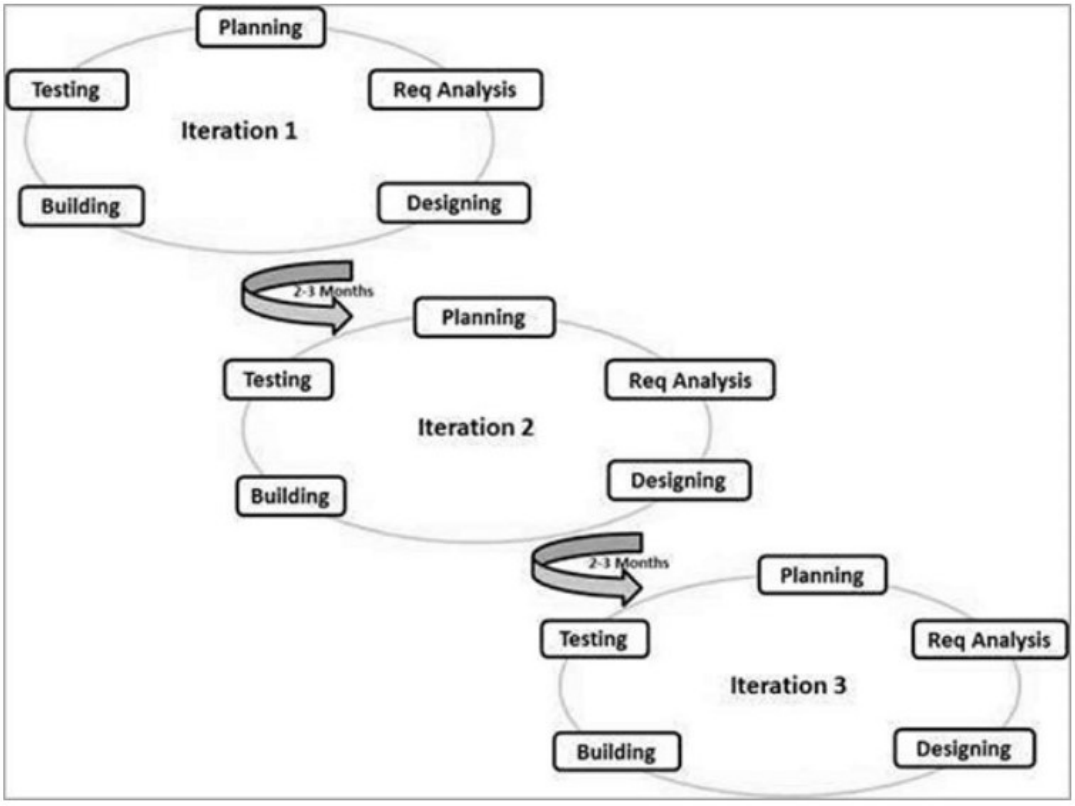

Figure 3.2: Image of Agile SDLC Model (tutorialpoint, n.d.)

3.1.3 Big Bang SDLC Model

Big Bang model is a model that do not have any specific development process. This kind of model is only putting time, efforts and resources at the starting point of the development as the input and output the system after the system is fully developed and ready to be deployed.

Besides that, Big Bang model only required very little planning and do not follow any specific development process during the development. Other than this, any changes

after the system is developed may or may not need to apply into the system. Hence, this kind of model is suitable for small project with limited number of developers such as academic projects.

In addition, there are several advantages of the Big Bang SDLC. The first advantage is this is a very simple model, so the whole process of development is relatively easy to manage. Besides that, Big Bang model also gives the developer flexibility to develop the system due to it do not follow any specific development process.

Nevertheless, there are also a few disadvantages which is by using Big Bang model will be having very high risks and uncertainty during and after the development. Besides that, Big Bang model is not suitable for large project due to little planning and unstandardized development process.

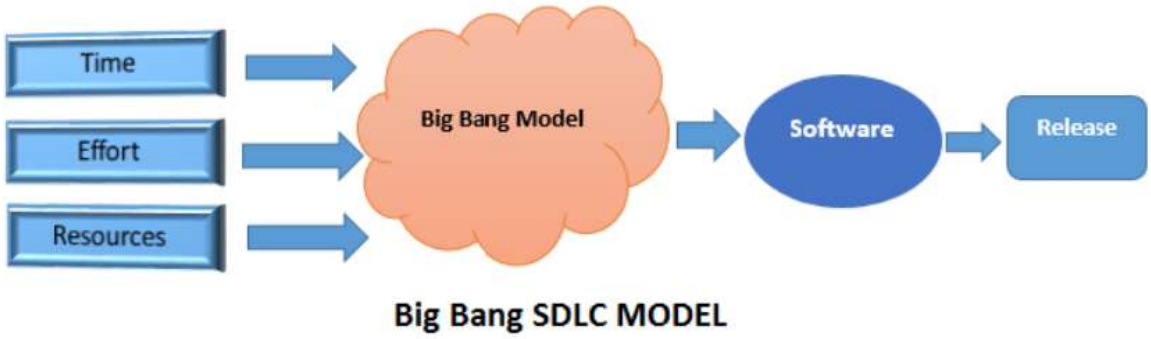

Figure 3.3: Image of Big Bang SDLC model (ProfessionalQA.com, 2019)

3.1.4 Selected Model

In this project, the selected model for the project development is Big Bang model. This is because the voice controlled mobile embedded device project is a small project and only require one developer. By choosing Big Bang model, the whole development process will be easy to manage and review. Besides that, due to the limited number of developer in this project, Iterative model and Agile model are considered as complex model to the project. Other than this, Big Bang model requires less development time compare to other 2 models which will spend a lot of time in the iterative processes. Moreover, due to the limited

number of developer, Big Bang model is most suitable since it only requires less number of developers.

3.2 System Requirement (Technologies Involved)

3.2.1 Hardware

3.2.1.1 GoPiGo

In this project, there are several hardware needed to build the Alexabot. The first hardware needed is GoPiGo which is body of the robot car. The GoPiGo will comes with GoPiGo3 Base Kit, Screwdriver for assembly, Raspberry Pi 3, GoPiGo Servo Package, Distance Sensor, microSD Card, 8GB USB Drive and Power Supply (Dexter Industries, 2019). Figure 3.4 shows the picture of GoPiGo.

Figure 3.4: The picture of GoPiGo (Dexter Industries, 2019).

3.2.1.2 Raspberry Pi 3

The second hardware is the Raspberry Pi 3. Raspberry Pi 3 is a single-board computer with Bluetooth connectivity and wireless LAN that acts as the brain of the robot car whose responsible to perform all the operations. Besides that, the CPU of the Raspberry Pi 3 is Quad Core 1.2GHz Broadcom BCM2837 64bits CPU. In addition, it comes with 4 USB 2.0 ports and a full size HDMI port. Figure 3.5 shows the picture of Raspberry Pi 3 while Figure 3.6 shows the details of the specification of Raspberry Pi 3.

Figure 3.5: The picture of Raspberry Pi 3 (Raspberrypi.org, 2019).

- Quad Core 1.2GHz Broadcom BCM2837 64bit CPU
- 1GB RAM
- BCM43438 wireless LAN and Bluetooth Low Energy (BLE) on board
- 100 Base Ethernet
- 40-pin extended GPIO
- 4 USB 2 ports
- 4 Pole stereo output and composite video port
- Full size HDMI
- CSI camera port for connecting a Raspberry Pi camera
- DSI display port for connecting a Raspberry Pi touchscreen display
- Micro SD port for loading your operating system and storing data
- Upgraded switched Micro USB power source up to 2.5A

Figure 3.6: The specification details of Raspberry Pi 3 (Raspberrypi.org, 2019).

3.1.2.3 3.5mm Audio Jack Speaker

The third hardware would be the speaker for the Raspberry Pi. The function of speaker is to provide the robot a voice and sound in order to reply to command giver. There is an aux jack on the Raspberry Pi to allow the speaker to connect to it. Besides that, users can adjust the volume of the speaker by using Raspberry Pi or the volume button on the speaker (Dexter Industries, 2019). Figure 3.7 shows the image of the speaker.

Figure 3.7: The speaker is connecting to the aux jack of the Raspberry Pi (Dexter Industries, 2019).

3.1.2.4 USB Microphone Dongle

The fourth hardware is USB microphone dongle for the Raspberry Pi. The function of USB microphone dongle is to let the command giver able to communicate with the Raspberry Pi with voice. Figure 3.8 shows the image of the USB microphone dongle.

Figure 3.8: The picture of USB microphone dongle (Dexter Industries, 2019).

3.2.2 Software

3.2.2.1 AlexaPi

AlexaPi is an Alexa voice service which purposely designed for Raspberry Pi by Amazon. According to (Amazon Alexa, n.d.), Alexa voice service is the service from Amazon that allow the user to access the cloud-based Alexa capabilities through the support of Alexa voice service APIs, software tools, hardware kits, and documentation. Figure 3.10 shows the image of Amazon Alexa logo.

Figure 3.10: The logo of Amazon Alexa (mobility, 2020.).

3.2.2.2 Alexa Skills Kit (ASK)

Alexa Skills Kit is a tool and platform for developer to develop Alexa skills sets. Developers can use the self-service APIs provided by the Alexa Skills Kit (ASK) to build their Alexa skills. Develop will need to use Python to write the lambda function in order to handle different intents of user. Figure 3.11 shows the image of Alexa Skills Kit (ASK).

Figure 3.11: The logo of Alexa Skills Kit

3.2.2.3 Ngrok

Ngrok is a service that allow a web server running on a local device to be exposed to the Internet (ngrok, n.d.). By using the Ngrok service, user will be able to access the web server running on the GoPiGo from the outside network. Figure 3.12 shows the image of Ngrok's logo.

Figure 3.12: The logo of Ngrok (axway, 2017)

3.2.2.4 Flask

Flask is a lightweight web application framework written in python to handle the web requests in the local device (The Pallet Projects, n.d.). Figure 3.13 shows the image of flask's logo.

Figure 3.13: The logo of flask (Flask, n.d.).

3.3 Functional Requirement

3.3.1 Voice Recognition Module

- Alexabot shall be able to recognize human speech.
- Alexabot shall only reply to user when the specific preamble word is called by the user.
- User need to call the specific preamble word and wait the reply from Alexabot, then only can give command.
- User shall be able to interact with Alexabot with voice command.

3.3.2 Online Searching Module

- Alexabot shall be able to connect to network.
- Alexabot shall be able to do online searching based on the command given by user.
- Alexabot shall be able to read out the document getting from online.

3.3.3 Robot Movement Module

- User shall be able to control the robot movement by using voice command.

3.4 Project Milestone

Task	Project Week													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Define Motivation and Problem statement, Project Objectives, Project Scope and Project Contributions														
Report current progress with supervisor														
Install raspbian into micro SD card														
Install AlexaPi into Raspberry Pi														
Configure AlexaPi														
Report current progress with supervisor														
Review current technologies														
Create applets on IFTTT														
Report current progress with supervisor														
Review current existing systems														
Install ngrok into Raspberry Pi														
Configure ngrok														
Report current progress with supervisor														
Define System Methodology														
Install flask into Raspberry Pi														

Write flask application														
Report current progress with supervisor														
Define system design														
Test the system														
Submit														
Presentation														

Table 3.2: Project Milestone for FYP1

Task	Project Week													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Define system implementation														
Craft the Alexa Skills for Alexa using Alexa Skills Kit														
Craft the Flask Server Program														
Define system evaluation and discussion														
Report current progress with supervisor														
Test and Recalibrate														
Submit														
Presentation														

Table 3.3: Project Milestone for FYP2

3.5 Estimated Cost

Items	For FYP Development	For Commercialisation
GoPiGo	RM 428.53	RM 428.53
Speaker	RM 34.95	RM 34.95
USB Microphone dongle	RM 20.00	RM 20.00
Ngrok	-	RM 248.07 / year

Table 3.4: Table of Estimated Cost

Chapter 4

System Design

4.1 System Architecture

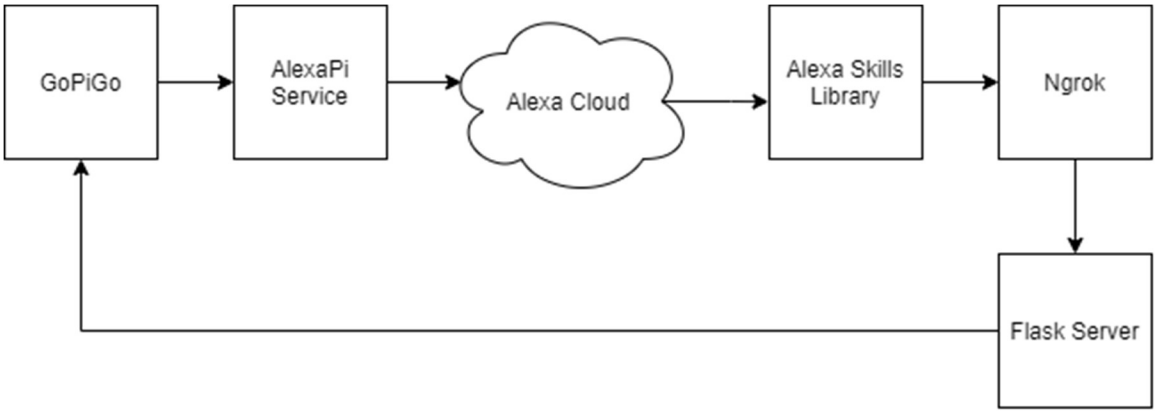

Figure 4.1: Block diagram of Alexabot System Architecture

4.2 Functional Modules in the System

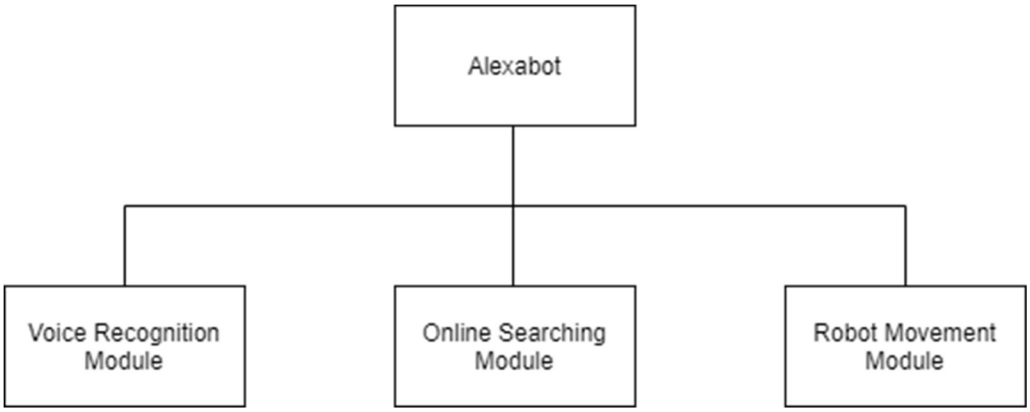

Figure 4.2: Diagram of Functional Modules in the System

4.3 System Flow

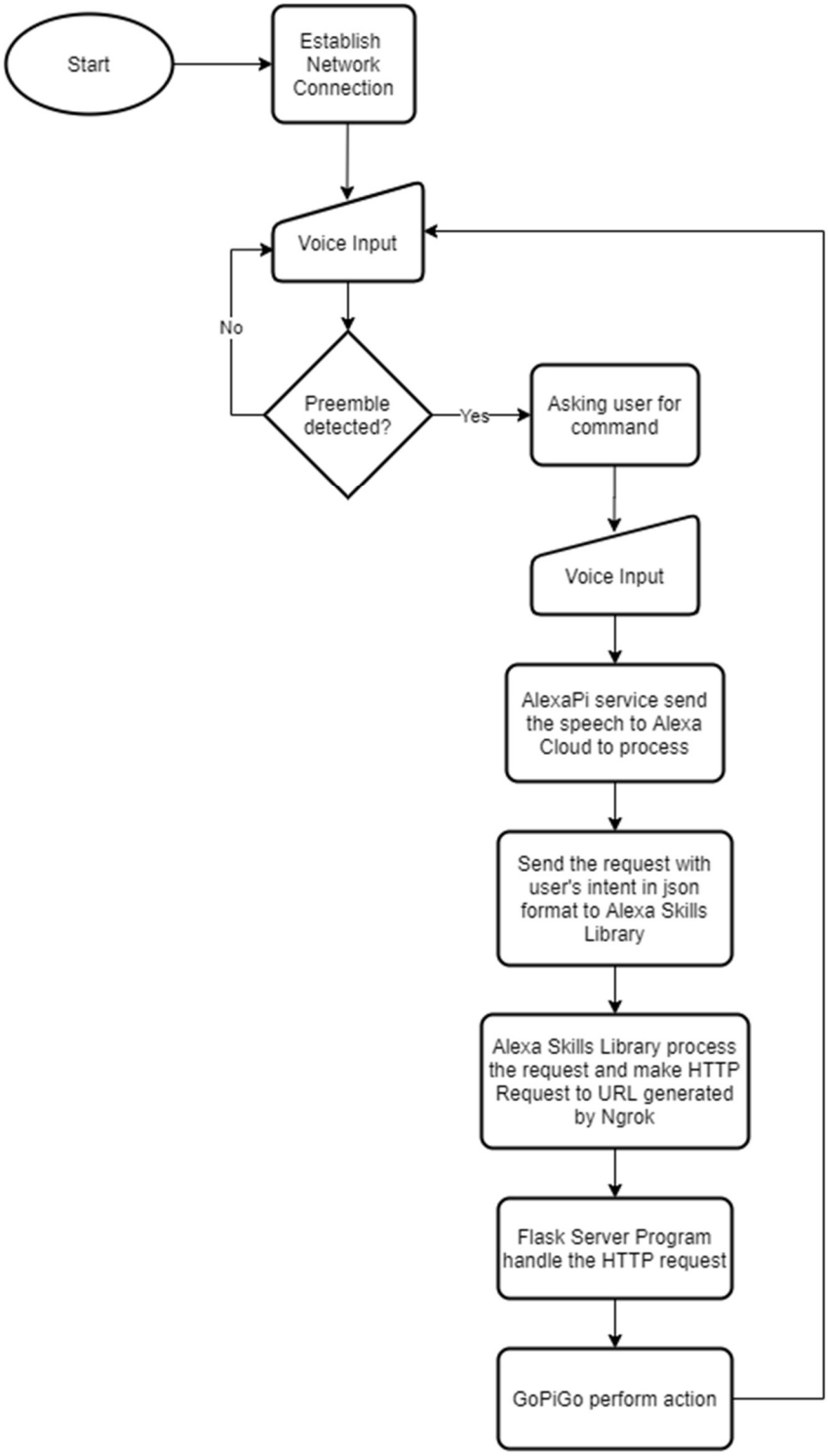

Figure 4.3: System flow of the Alexabot

Chapter 5

System Implementation

5.1 Hardware Setup

5.1.1 GoPiGo connect with USB Microphone Dongle

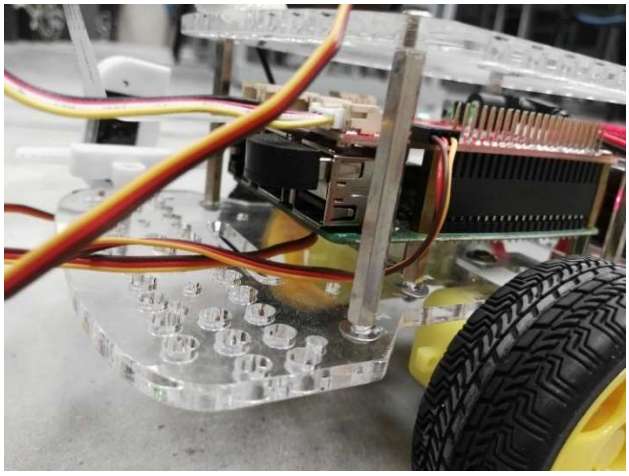

Figure 5.1.1: USB Microphone Dongle connected to Alexabot

Figure 5.1.1 shows that the USB microphone dongle is connected to Alexabot through the USB port on the GoPiGo.

5.1.2 GoPiGo connect with 3.5mm Audio Jack Speaker

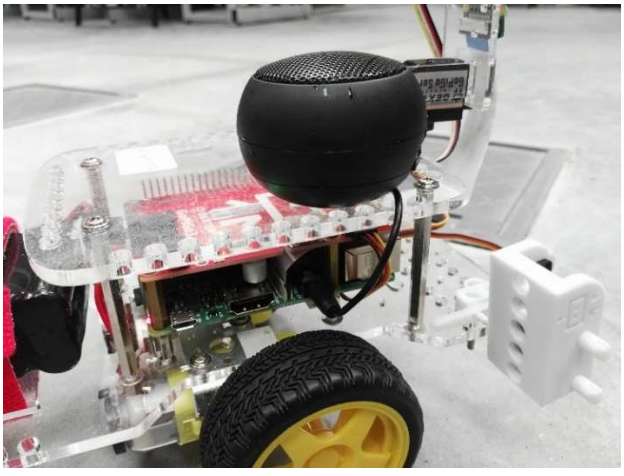

Figure 5.1.2: 3.5mm Audio Jack Speaker connected to Alexabot

Figure 5.1.2 shows that the 3.5mm audio jack speaker is connected to Alexabot through the 3.5mm audio jack port.

5.2 Software Setup

5.2.1 Raspbian OS Installation

To install the Raspbian OS into GoPiGo, there are a few steps need to follow:

1. Prepare a micro SD card with at least 8GB storage.
2. Download the latest version of Raspbian OS image file at the website: https://www.dexterindustries.com/howto/install-raspbian-for-robots-image-on-an-sd-card/
3. Download the latest version of Etcher at https://www.balena.io/etcher/
4. Put the micro SD card into the card reader slot on the laptop.
5. Open the Etcher program on laptop, click the "Select image" and file the Raspbian OS image file. After that, click the "Select target" and select the micro SD card. Next, click the "Flash!" button and wait for the Etcher to flash the Raspbian OS into the micro SD card. Figure 5.2.1.1 shows the interface of Etcher program.
6. Unplug the micro SD card from the laptop, plug the micro SD card into the micro SD card slot on the GoPiGo.
7. Connect mouse and keyboard to the USB port on the GoPiGo and monitor through HDMI port.
8. Startup the GoPiGo and follow the instruction to complete the first-time startup configuration.

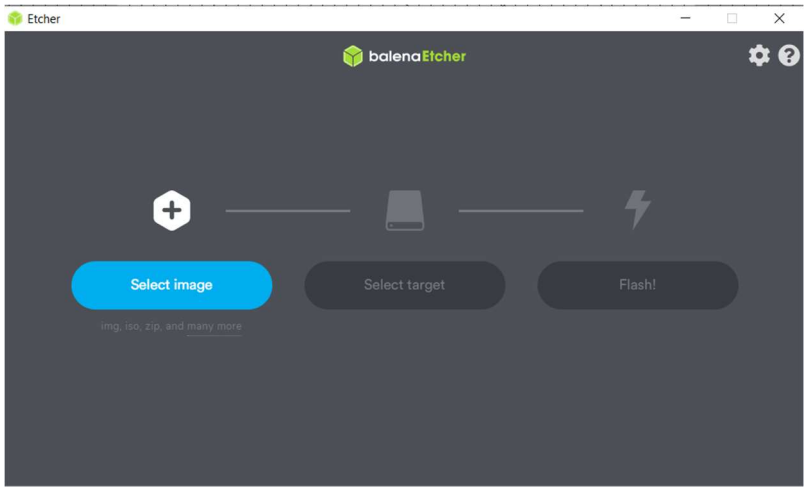

Figure 5.2.1.1: Etcher program interface

5.2.2 AlexaPi Service Installation

To install AlexaPi Service into GoPiGo, there are a few steps need to follow:

1. Register an Amazon account at https://developer.amazon.com
2. After registration completed, click "Alexa Voice Service" button show in the figure 5.2.2.1. After that click the "Product" button show in the figure 5.2.2.2. After that, click the "ADD NEW PRODUCT" button at the top right show in the figure 5.2.2.3. Next, define a Product ID.
3. After product is successfully created, Client ID, Client Secret, Security Profile description and Security Profile ID will be auto generated. Record all of them.
4. Go to GoPiGo, open up a terminal and type "cd /opt"
5. Type "sudo apt-get install git" to make sure git is installed in the GoPiGo
6. Type "sudo git clone https://github.com/alexa-pi/AlexaPi.git" to clone the AlexaPi Service repository.
7. Type "sudo ./AlexaPi/src/scripts/setup.sh" to start the AlexaPi Service installation.
8. Follow the instruction during the AlexaPi Service installation. Type in the Client ID, Client Secret, Security Profile description and Security Profile ID when the installation is needed.

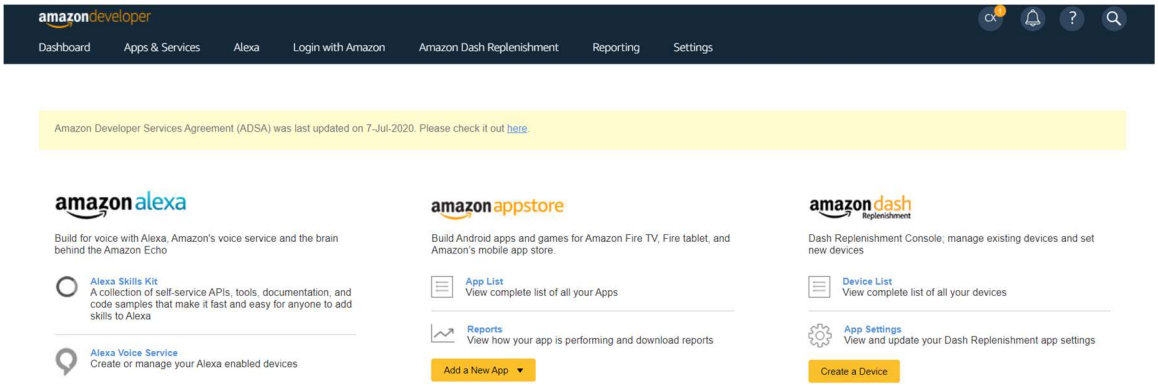

Figure 5.2.2.1: Amazon Developer Interface

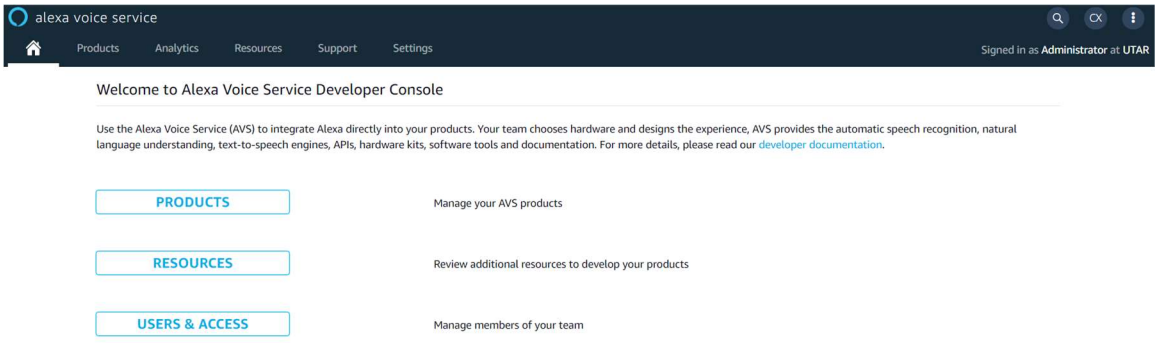

Figure 5.2.2.2: Alexa Voice Service Interface

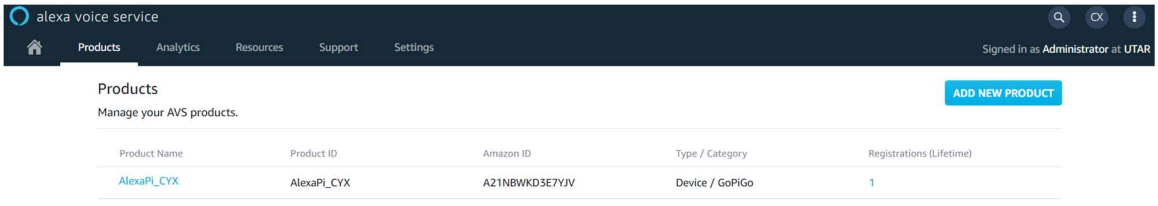

Figure 5.2.2.3: Alexa Voice Service Interface

5.2.3 Ngrok Installation

To install Ngrok into GoPiGo, there are a few steps need to follow:

1. Register a Ngrok account at https://ngrok.com/
2. After registration, an authentication token command will be auto generated in the "Setup & Installation page show in the figure 5.2.3.1. Record down the authentication token command.
3. Go to GoPiGo and open up a terminal, type "mkdir ~/ngrok"
4. Type "cd ~/ngrok"
5. Type "sudo wget https://bin.equinox.io/c/4VmDzA7iaHb/ngrok-stable-linux-arm.zip"
6. Type the recorded authentication token command.

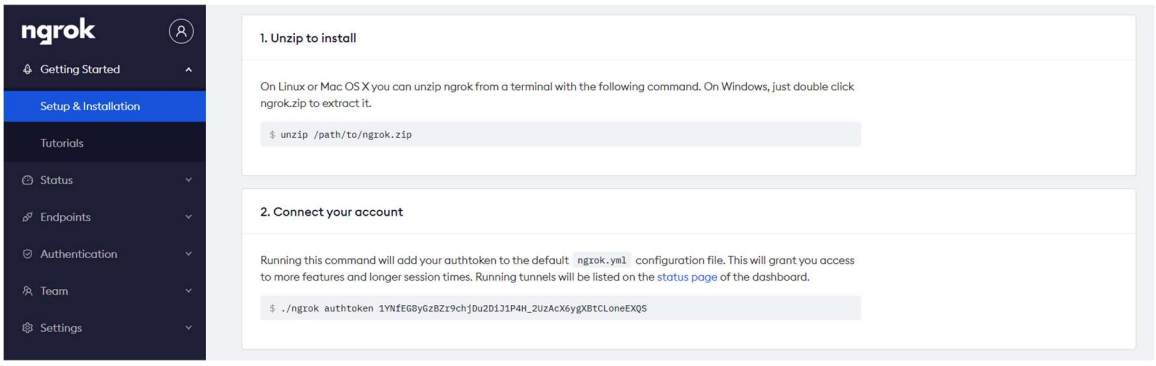

Figure 5.2.3.1: Auto generated authentication token command by Ngrok

5.2.4 Flask Server Installation and Flask Program

To install Flask Server and create the Flask Program into GoPiGo, there are a few steps need to follow:

1. Open a terminal in GoPiGo, type “sudo pip install flask” to install the flask server
2. Write a Flask Program using Python to handle the HTTP request and control the GoPiGo. Figure 5.2.4.1 show a code snippet of Flask Program.

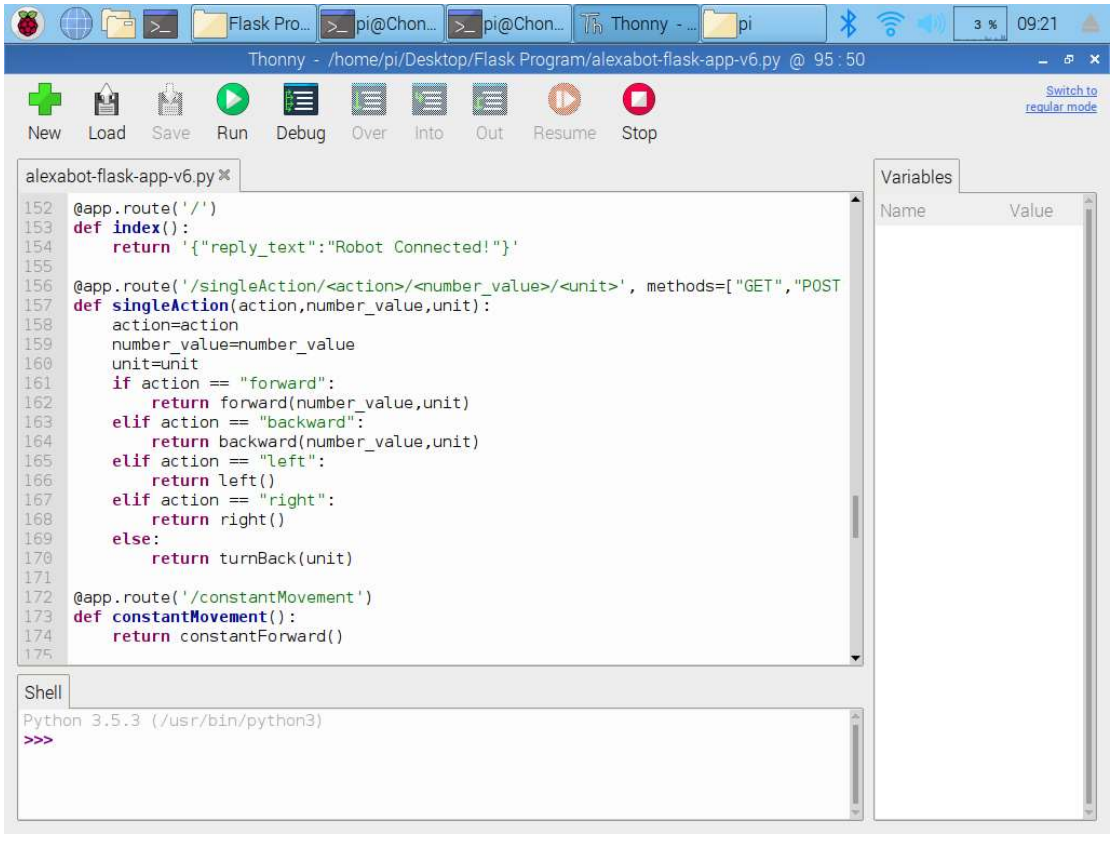

Figure 5.2.4.1: Code snippet of Flask Program

5.2.5 Alexa Skills Library Development

To craft the Alexa Skills Library, there are a few steps need to follow:

1. Go to https://developer.amazon.com/alexa/console/ask and click the "Create Skill" button. Figure 5.2.4.1 shows the interface of Alexa Developer Console.
2. Define the skill name, and follow the selection shown in the Figure 5.2.4.2. After that click the "Create skill" button at the top right.
3. Select the "Hello World Skill" and click the "Continue with template" button at the top right.
4. Create the intents and sample utterances shows in the Figure 5.2.4.3.
5. Click the "Code" button and start to create lambda function using Python in the console. Figure 5.2.4.4 shows the code snippet of lambda function.

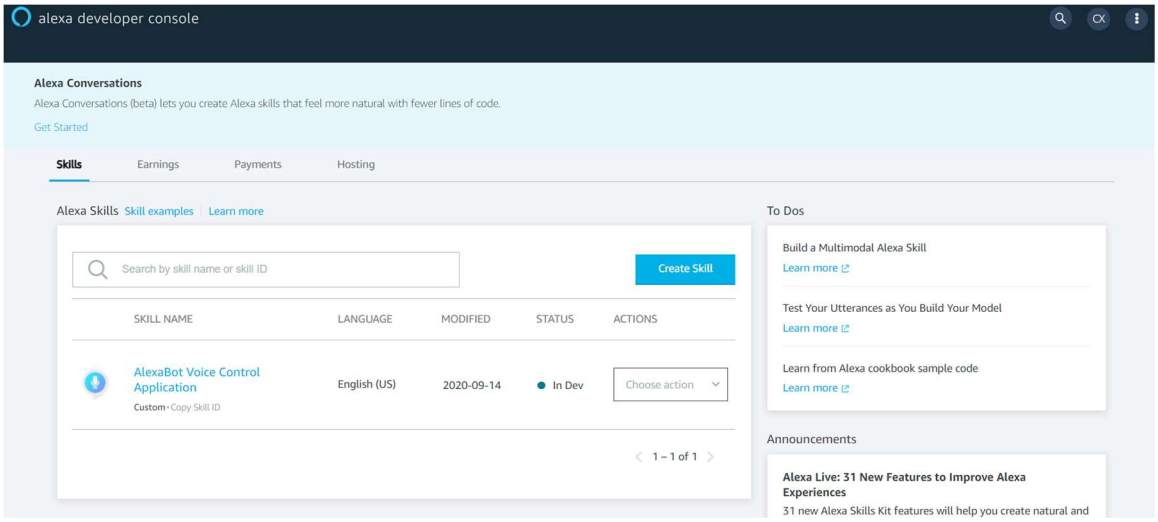

Figure 5.2.5.1: Interface of Alexa Developer Console

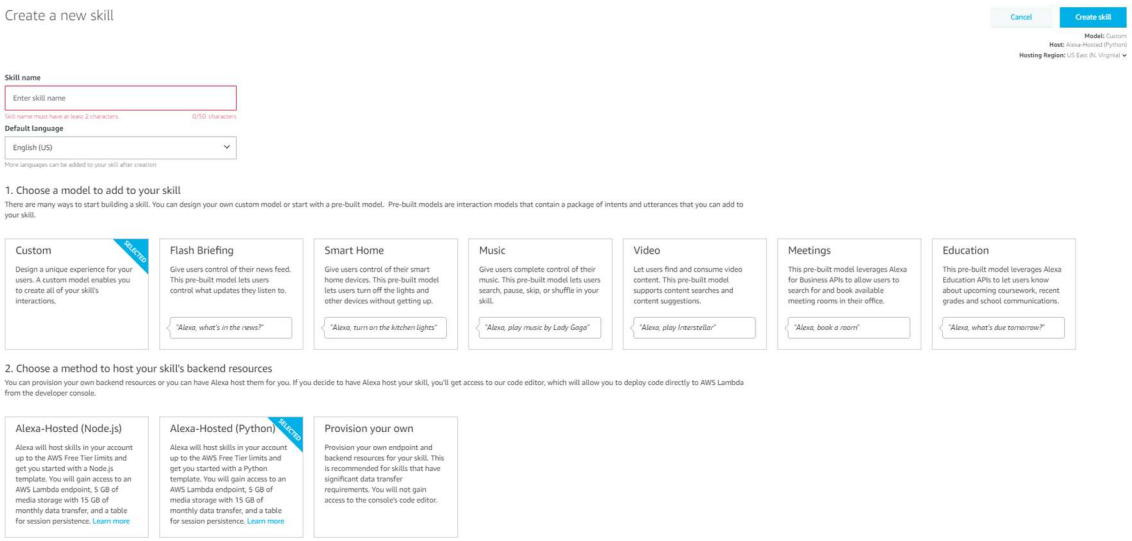

Figure 5.2.5.2: Interface of Alexa Developer Console

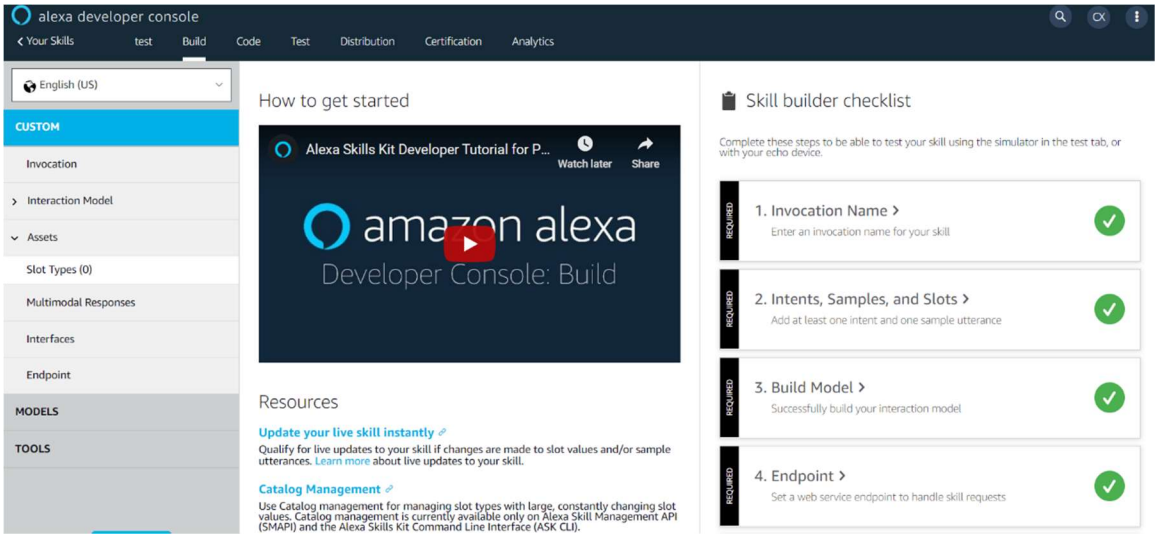

Figure 5.2.5.3: Interface of Alexa Skill Console

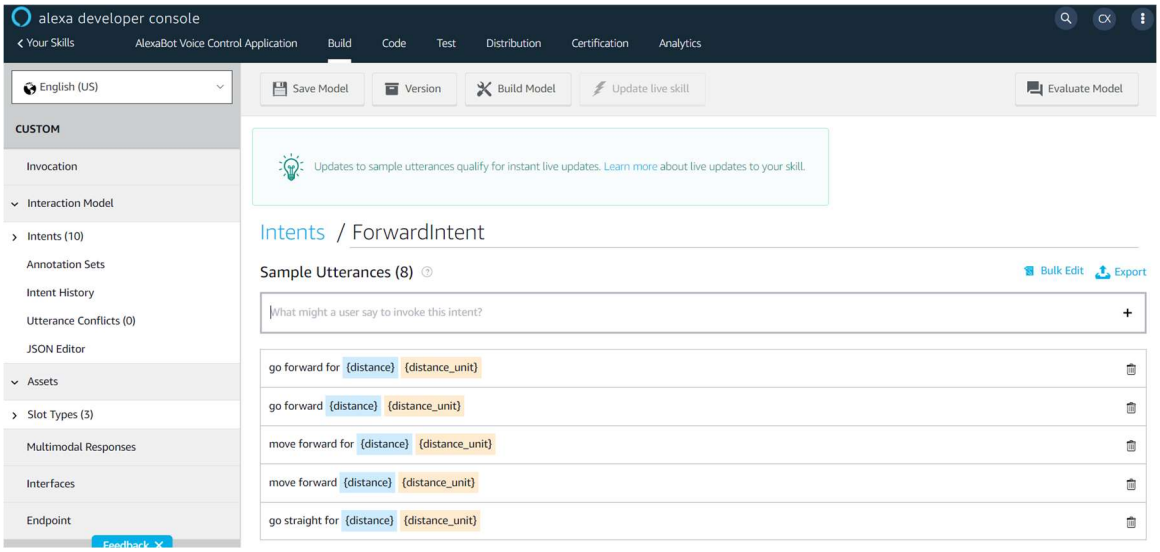

Figure 5.2.5.4: Interface of Intents and Utterances Development

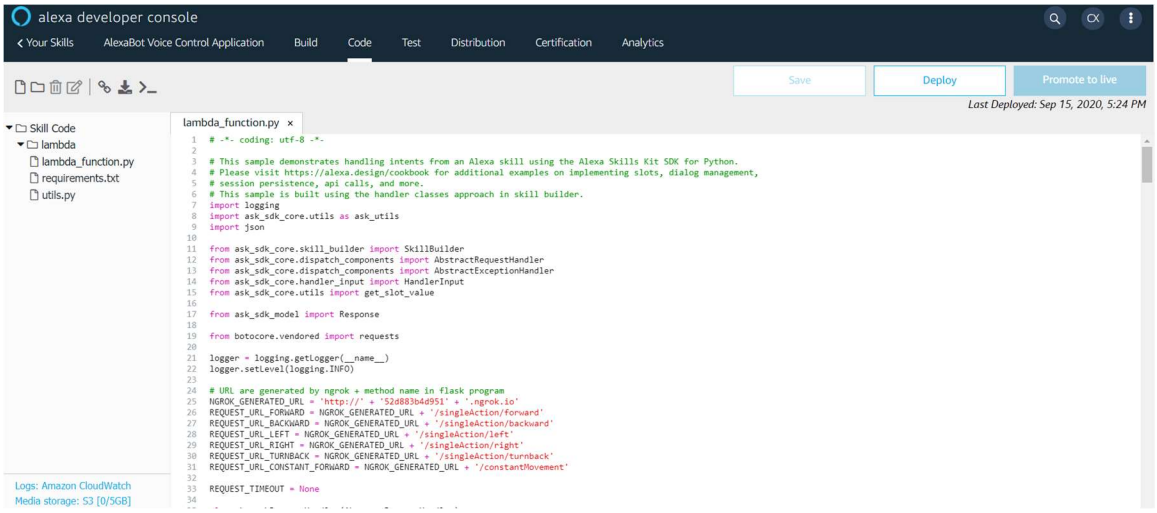

Figure 5.2.5.5: Code snippet of lambda function

5.3 Setting and Configuration

There are a few steps to setting and configure before the AlexaBot start to work. The setting and configuration can be divided into three parts which are Ngrok, Flask server and AlexaPi service.

Firstly, start the Ngrok by follow the steps below:

1. Open terminal in GoPiGo, type “cd ~/ngrok”
2. Type “./ngrok http 5006” to start the Ngrok.
3. Due to the Ngrok account is using free plan, an auto-generate URL will be generated in the console shows in the Figure 5.3.1.
4. Record down the auto-generated URL and leave the terminal remain open.
5. Replace the old auto-generated URL in the lambda function program shows in the Figure 5.2.4.5 with the new auto-generated URL.

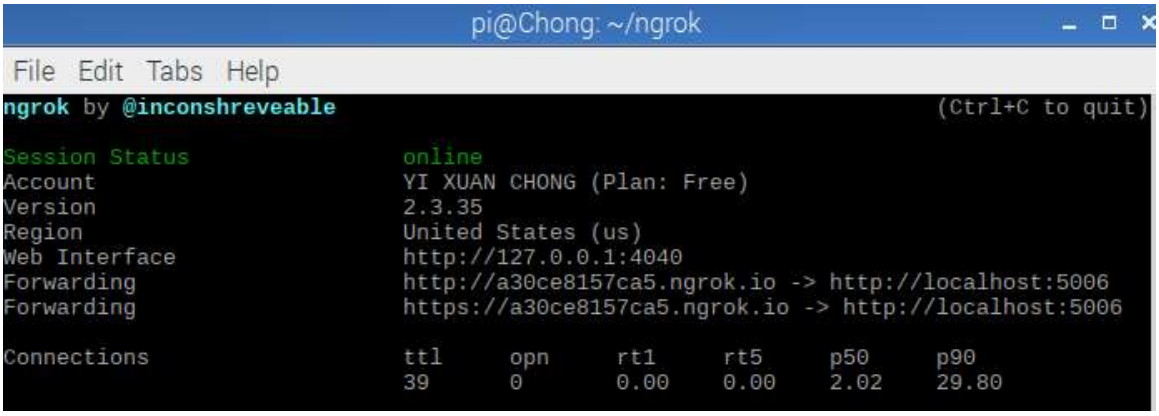

Figure 5.3.1: Console shows after Ngrok is started

Secondly, host the Flask program by follow the steps below:

1. Open a new terminal in GoPiGo, type “python3 alexabot-flask-app-v6.py” to start to host the flask program. Figure 5.3.2 shows the console after the flask program is started.
2. Leave the terminal remain open.

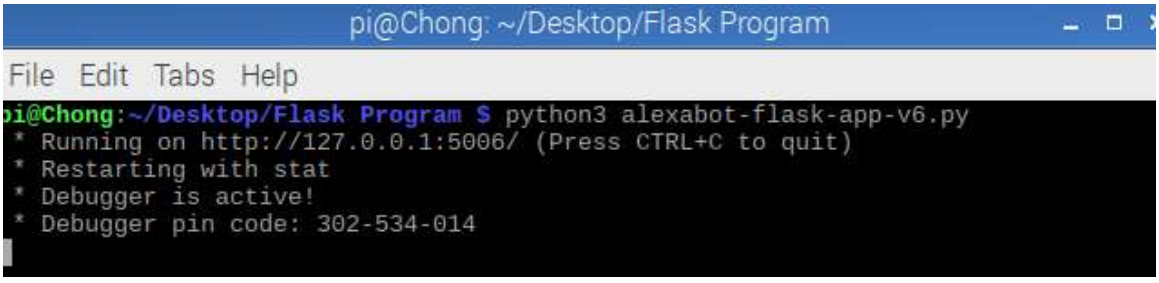

Figure 5.3.2: Console shows after flask program is started

Thirdly and finally, start the AlexaPi service by follow the steps below:

1. Open a new terminal in GoPiGo, type “cd /opt/AlexaPi/src” to locate the AlexaPi service program location.
2. Type “python3 main.py -d” to start the AlexaPi service.
3. Leave the terminal remain open.

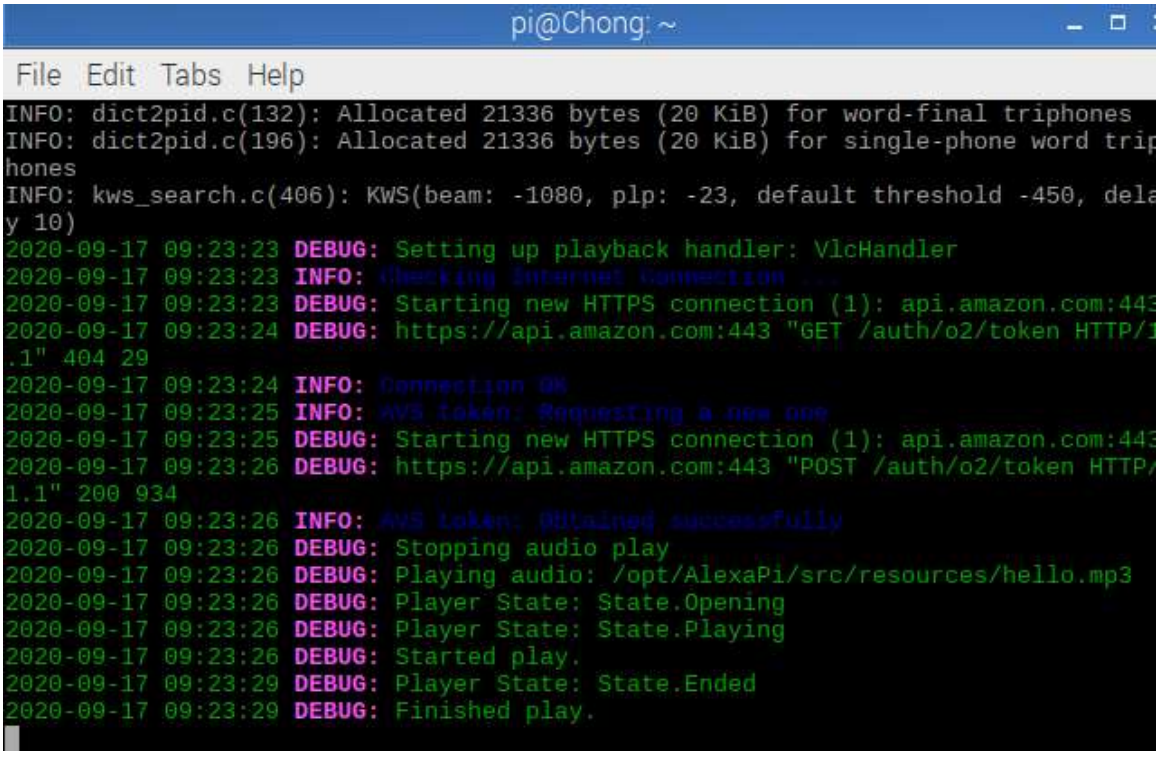

Figure 5.3.3: Console shows after AlexaPi service program is started

5.4 System Operation

After the hardware setup, software setup, setting and configurations are done, the user can start to give command to the AlexaBot by using speech. When the user give command to AlexaBot. To start using the crafted Alexa Skills Library, a lunch request is needed, so, user have to say the skill’s invocation name to AlexaBot. The invocation command is “voice robot”. AlexaPi service will send the speech to the Alexa Service in cloud to interpret the user’s intent. User can monitor the process through the terminal show in the Figure 5.4.1.

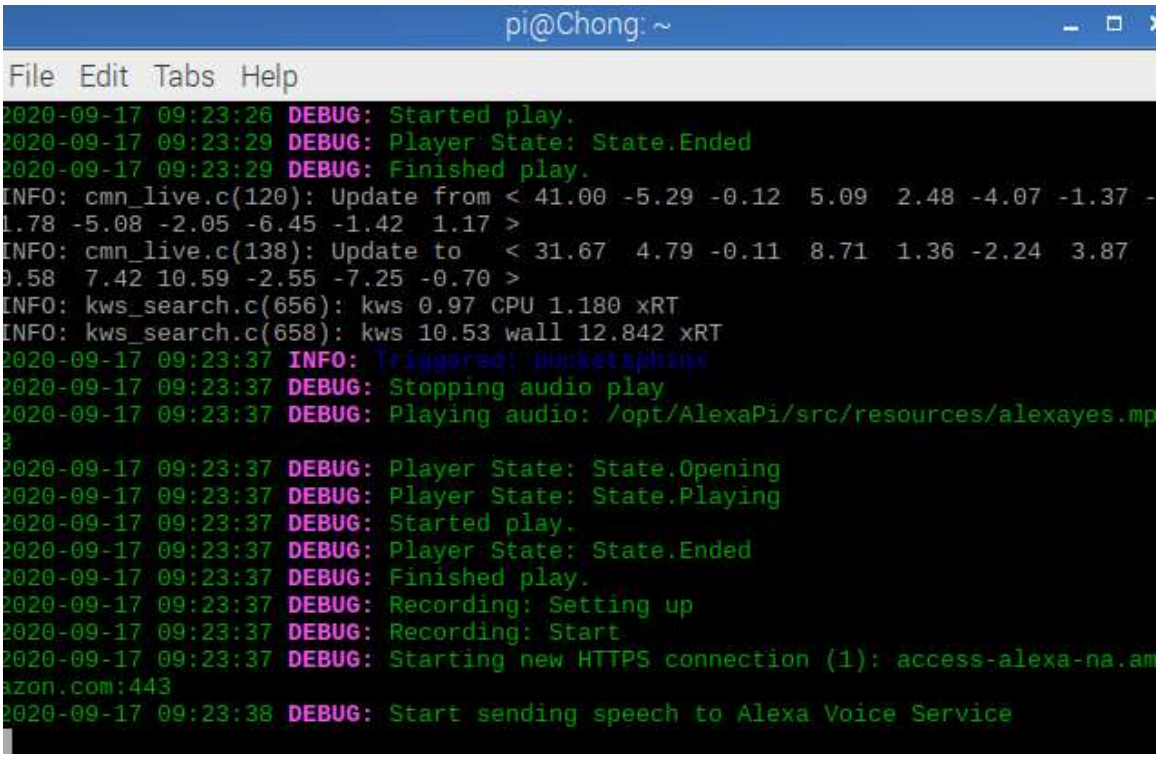

Figure 5.4.1: Terminal in GoPiGo that running AlexaPi Service Program

After the Alexa Service in the cloud interpreted the speech's intent, Alexa Service will generate and send a launch request in json format to the Alexa Skills Library. The lambda function that represent this skill will process the launch request and send a response in json format. Figure 5.4.2 shows the code snippet of the launch request in json format. Figure 5.4.3 shows the code snippet of the response from lambda function in json format.

JSON Input 1

```
{
    "version": "1.0",
    "session": {
        "new": true,
        "sessionId": "amzn1.echo-api.session.6d3fc99c-7e38-465c-
        "application": {
            "applicationId": "amzn1.ask.skill.44d1e8e6-ad14-4656
        },
        "user": {
            "userId": "amzn1.ask.account.AHSJY2RRLYSSRA4HDNGNHPH
        }
    },
    "context": {
        "Viewports": [
            {
                "type": "APL",
                "id": "main",
                "shape": "RECTANGLE",
                "dpi": 160,
                "presentationType": "STANDARD",
                "canRotate": false,
                "configuration": {
                    "current": {
                        "video": {
                            "codecs": [
                                "H_264_42",
                                "H_264_41"
                            ]
                        },
                        "size": {
                            "type": "DISCRETE",
                            "pixelWidth": 1024,
                            "pixelHeight": 600
```

Figure 5.4.2: Code snippet of the launch request in json format

JSON Output 1

```
{
    "body": {
        "version": "1.0",
        "response": {
            "outputSpeech": {
                "type": "SSML",
                "ssml": "<speak>Robot Connected! Hello, welcome to
            },
            "reprompt": {
                "outputSpeech": {
                    "type": "SSML",
                    "ssml": "<speak>Robot Connected! Hello, welcom
                }
            },
            "shouldEndSession": false,
            "type": "_DEFAULT_RESPONSE"
        },
        "sessionAttributes": {},
        "userAgent": "ask-python/1.11.0 Python/3.7.9"
    }
}
```

Figure 5.4.3: Code snippet of the response from lambda function

After the AlexaBot receive the response from lambda function, the crafted Alexa Skills Library is activated. Now, user can start to give command to AlexaBot by using speech to control the movement of AlexaBot. For example, “Alexa, move forward for one meter”. After the AlexaBot receive the command, AlexaPi service will send the speech to Alexa service in cloud to interpret. After interpretation, the Alexa service in cloud will generate an intent request with user’s intent in json format to the Alexa Skills Library’s lambda function to process. During the processing, the lambda function will make a HTTP request to the flask program using the URL generated by Ngrok. Figure 5.4.4 shows the flask server receive and start to handle the HTTP request from lambda function.

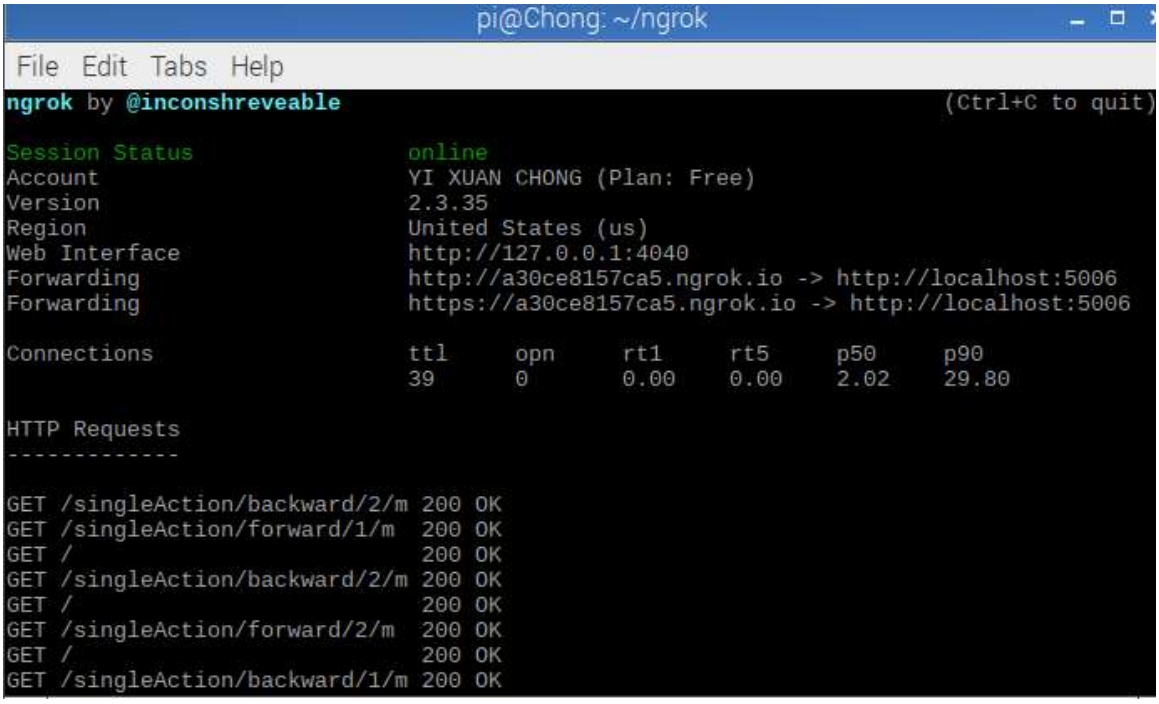

Figure 5.4.4: Console shows the flask server receive a HTTP request

When the flask program completed the request, it will send a response back to lambda function. After lambda function receive the response from flask server, it will generate a response in json format and send it back to AlexaPi service.

5.5 Concluding Remark

In Chapter 5, hardware setup part shows how to setup the AlexaBot with USB microphone dongle and 3.5mm audio jack speaker while the software part list down all the steps to install the require software and services. Besides that, all the setting and configuration are also included in this chapter. Last, the system operation part shows the full operation flow from user give command until the robot move.

Chapter 6

System Evaluation and Discussion

6.1 System Testing and Performance Metrics

In the AlexaBot development, there are two types of testing are used which are accuracy testing and reliability testing to test the system and the performance. During the accuracy testing, there are four categories were tested which are distance, direction, distance with direction and moving duration. These four categories were tested to ensure the accuracy of the AlexaBot is higher.

Next, is the reliability testing. During the reliability testing, the response time from the Alexa was tested with different types and complexity of the commands. Besides that, a single command is also used to test the successful recognized rate of AlexaBot. By testing the AlexaBot using reliability testing, it will help to ensure that the response time of the Alexa will not be too long.

All the system testing methods were tested on Alexa developer console show in the Figure 6.1.1 due to the unstable of AlexaPi service problem.

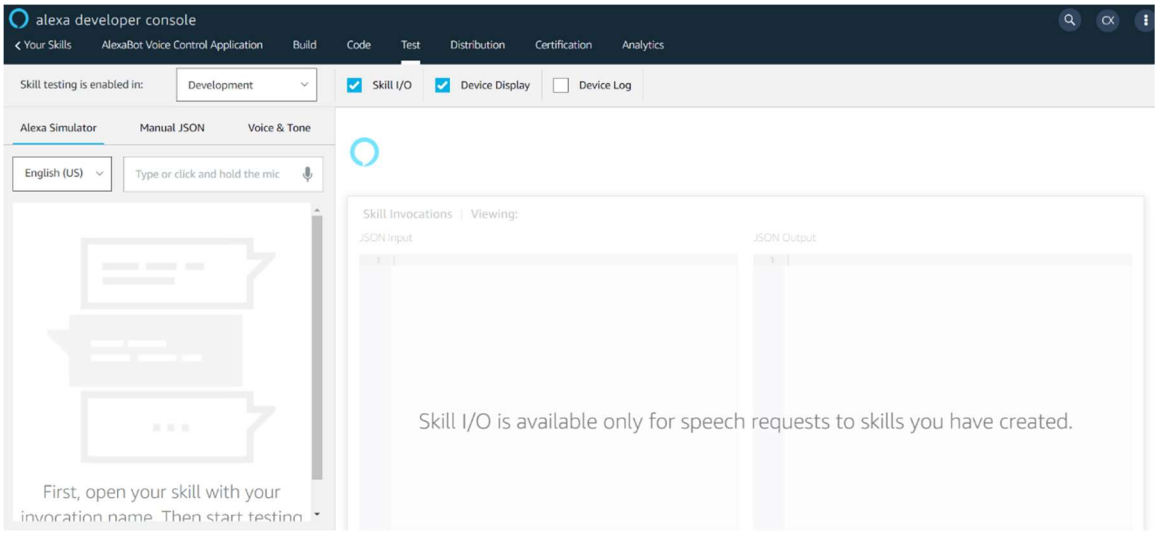

Figure 6.1.1: Interface of Alexa Development Console

6.2 Testing Setup and Result

6.2.1 Accuracy Testing

In the accuracy testing, there are three types of testing are included which are distance testing, direction testing and moving duration testing. The distance testing is to get the different in meter between the requested moving distance and the actual moving distance while the direction testing is to get the degree changes after turning. Besides that, moving duration testing to get the different in second between the requested moving duration and the actual moving duration.

6.2.1.1 Distance

Requested Moving Distance (m)	Actual Moving Distance (m)	Different between Requested Moving Distance and Actual Moving Distance (m)
1.00	0.97	0.03
2.00	1.94	0.06
3.00	2.90	0.10
4.00	3.87	0.13
5.00	4.82	0.18

Table 6.1: Distance between Requested Moving Distance and Actual Moving Distance

Based on the result of distance testing shows in the Table 6.1, the average distance different between requested moving distance and actual moving distance is 0.01 meter.

6.2.1.2 Direction

This direction testing is conducted using the degree from the direction the AlexaBot is facing at the beginning to the direction the AlexaBot is facing after turning. The direction that the AlexaBot original facing is 0 degree. If the AlexaBot turn left or right, the degree must be 90 degrees. If turn to back, the degree must be 180 degrees.

Requested Direction	Degrees from Starting Direction
Left	88
Right	88
Back	176

Table 6.2: Degree from Starting Direction

6.2.1.3 Moving Duration

Requested Moving Duration (s)	Actual Moving Duration (s)	Different between Actual Moving Duration and Requested Moving Duration (s)
2	2.02	0.02
4	4.01	0.01
6	6.07	0.07
8	8.07	0.07
10	10.04	0.04
12	12.10	0.10
14	14.00	0
16	16.05	0.05
18	18.08	0.08
20	20.09	0.09

Table 6.3: Different between Actual Moving Duration and Requested Moving Duration

Based on the result of the moving duration testing shows in the Table 6.3, the average moving duration different between actual moving duration and requested moving duration is 0.053 seconds.

6.2.2 Reliability Testing

In the reliability testing, there are two types of testing are included. The first type of testing is to get the Alexa's response time by using simple action command without value and complex action command with value while the second type of testing is getting the recognition rate by using a single command with multiple times.

6.2.2.1 Response Time for Simple Action Command without Value

Command	Response Time (s)
Forward	1.57
Backward	1.22
Left	1.13
Right	0.89

Table 6.4: Response Time with Simple Action Command given

Based on the result of the simple action command without value response time testing shows in the Table 6.4, the average response time is 1.2025 seconds.

6.2.2.2 Response Time for Complex Action Command with Value

Command	Response Time (s)
Forward for one meter	1.79
Backward for one meter	1.89
Move forward for two meters	1.81
Move backward for two meters	1.82

Table 6.5: Response Time with Complex Action Command given

Based on the result of the complex action command with value response time testing shows in the Table 6.5, the average response time is 1.8275 seconds.

6.2.2.3 Recognition Rate

A command, “can you forward for one meter” is used to conduct the testing.

Frequency	Able to Recognize
1	Yes
2	Yes
3	Yes
4	Yes
5	Yes
6	Yes
7	Yes
8	Yes
9	Yes
10	Yes

Table 6.6: Result of Able to Recognize a Single Command in Multiple time

Based on the result of the recognition rate testing shows in the Table 6.6, the recognition success rate is 100%.

6.3 Project Challenges

During the project development, there are several challenges has occurred. The first challenge is the robot can only handle one command at a time. By having this problem, the user needs to follow the robot in order to give the robot next command.

Other than this, the second challenge is difficult to interrupt the robot. When the robot is performing given task, user will find it not easy to interrupt the robot by giving another command. This is because when the robot is moving, the motors will produce noise, so that the USB microphone dongle is difficult to hear human voice since the motors is closer to the microphone compare to user.

Besides that, free account of Ngrok will also increase the steps for initialization. For free account on Ngrok, each time running the Ngrok will generate a random URL and the user need to manually replace the URL in the lambda function in the Alexa Skills Library.

Moreover, when making HTTP request in the lambda function, all the HTTP response will need to response in less than 7.5 seconds. So, if the flask server program need to process more than 7.5 seconds or the network is not stable, the Alexa will prompt error to user and said that the request response is error.

Furthermore, the AlexaPi service that installed in the AlexaBot is not stable due to the program problem. When user give command to the AlexaBot, most of the time the AlexaPi service will prompt error or not responding.

6.4 Objectives Evaluation

The first project objective of this project is to develop a voice-controlled robot to receive commands given by the user using speech. This objective is successful achieved in this voice-controlled robot project. Because, the AlexaBot is developed by integrated with AlexaPi service, so the AlexaBot can receive and react to user speech and command through the AlexaPi service.

The second project objective of this project is to integrate Amazon's Alexa service into the voice-controlled robot. This objective is partially achieved in this voice-controlled robot project because the AlexaPi service is successfully installed into the AlexBot. However, the AlexaPi service is not stable due to the problem of AlexaPi service program itself. To solve this problem, the AlexaPi service in the Alexa Developer Console in the Alexa's official website is used to temporary replace the role of AlexaPi service in the AlexaBot. Although the AlexaPi service in the AlexaBot is replaced with the one in Alexa Developer Console, the main idea of integrating AlexaPi service to voice-controlled robot is still the same.

The third project objective of this project is to craft the Alexa Skills sets to handle different commands given by user using Alexa Skill Kit. This objective is successfully achieved in this voice-controlled robot project. Alexa Skills sets are successfully crafted using the lambda function in the Alexa Skills Library. The Alexa Skill sets can handle the more natural command given by the users because the Alexa Skill is able to predefine sample utterances for each intent. In the sample utterances, custom slot type is implemented to accept different value from the user in order to ensure the scalability of the command.

The last project objective of this project is to implement this Alexa based robot-controlled robot to move forward, backward and turn left, right. This objective is successful achieved in this voice-controlled robot project by implementing the AlexaBot with AlexaPi service, crafted lambda function in the Alexa Skills Library, flask server and Ngrok. When user give command to the AlexaBot, the AlexaPi service will send the speech to the Alexa Voice Service in cloud to process. After the processing is done, The Alexa Voice Service will send request with user's intent to the Alexa Skills Library, and the crafted lambda dunction will process the request and make HTTP request to the Flask server through the URL generated by the Ngrok. And the flask program in the AlexaBot will responsible for the movement of the robot.

Chapter 7

Conclusion and Recommendation

7.1 Conclusion

In conclusion, this project is to create an Alexa based voice-controlled robot with robotic arm that integrated with Amazon's Alexa voice service. The main objective of this project is to let the user to be able to control the robot to move by using voice command instead of using hands.

Besides that, the components of the robot are GoPiGo3, Raspberry Pi, 3.5mm audio jack speaker and USB microphone dongle. All the components listed above are suitable for a robot because of the size and the cost.

Other than this, this project will also come out with some functional requirement modules which are voice recognition module, online searching module and robot movement module. Moreover, the development model for this project is Big Bang Model due to the concept of Big Bang model is most suitable to small project.

In addition, challenges also occurred during the development process, such as only one command at a time, difficult to interrupt robot when the robot is performing another task, HTTP response need to be less than 7.5 seconds and unstable of AlexaPi service. Moreover, the performance of the accuracy testing and reliability testing are above average.

In the end, a voice-controlled robot is developed. However, the AlexaPi service program is not stable and there are many more to improve.

7.2 Recommendation

In this voice-controlled mobile embedded device project, there are still many more to improve and enhance. The accuracy testing may not be very accurate due to the testing is perform at a flat and smooth surface due to the restriction of network coverage is only in the lab. So, a SIM card dongle can be integrated to overcome the network coverage restriction.

Besides that, the AlexaPi service is not stable. So, an update is needed in the future when the official website releases the new version of AlexaPi service. Other than this, a robotic arm is also recommended to integrate with the AlexaBot in order to provide the grabbing ability to the AlexaBot.

Bibliography

Bilmes, J., Li, X., Malkin, J., Kilanski, K., Wright, R., Kirchhoff, K., Subramanya, A., Harada, S., Landay, J., Dowden, P. and Chizeck, H. (2005). The Vocal Joystick: A Voice-Based Human-Computer Interface for Individuals with Motor Impairments.

Brenman, L., 2017. *Arrow Builder Debugging Tip - Ngrok Secure Tunnel To Localhost*. [online] Axway Developer Blog. Available at: <https://devblog.axway.com/apis/arrow-builder-debugging-tip-ngrok-secure-tunnel-to-localhost/>

Cytron Technologies Malaysia. (n.d.). *Robot Arm Building Block (w/o micro:bit)*. [online] Available at: https://my.cytron.io/p-robot-arm-building-block-w-o-micro-bit?src=search.list

Developer.amazon.com. n.d. *Alexa Voice Service*. [online] Available at: <https://developer.amazon.com/en-US/alexa/alexa-voice-service>

Dexter Industries. (2019). *Alexabot: Amazon Alexa Controlled Robot With the Raspberry Pi*. [online] Available at: https://www.dexterindustries.com/projects/alexabot-amazon-alexa-controlled-robot/

Dexter Industries. (2019). *GoPiGo Beginner Starter Kit: the Raspberry Pi Robot Car*. [online] Available at: https://www.dexterindustries.com/product/gopigo-beginner-starter-kit/

Dexter Industries. (2019). *Speaker for the Raspberry Pi*. [online] Available at: https://www.dexterindustries.com/product/speaker-for-the-raspberry-pi/

Finch, C. (n.d.). *The Disadvantages of Voice Recognition Software*. [online] Techwalla. Available at: https://www.techwalla.com/articles/the-disadvantages-of-voice-recognition-software

Flask.palletsprojects.com. (n.d.). *Welcome to Flask — Flask Documentation (1.1.x)*. [online] Available at: https://flask.palletsprojects.com/en/1.1.x/

Furukawa, M. (n.d.). *Voice Controlled Toy*. 4717364.

House, B., Malkin, J. and Bilmes, J. (2009). The VoiceBot: a voice controlled robot arm.

Kannan, K. and Selvakumar, D. (2015). Arduino Based Voice Controlled Robot. 02(01).

Ngrok.com. n.d. *Ngrok – Documentation*. [online] Available at: <https://ngrok.com/docs>

Norberto Pires, J. (2005). Robot-by-voice: experiments on commanding an industrial robot using the human voice. *Industrial Robot: An International Journal*, 32(6), pp.505-511.

Mobility India. n.d.. *Amazon Introduces Voice Powered By Alexa To Enhance Shopping - Mobility India*. [online] Available at: <http://www.mobilityindia.com/amazon-introduces-voice-powered-by-alexa-to-enhance-shopping/>

Pallets. n.d. *Flask*. [online] Available at: <https://palletsprojects.com/p/flask/>

Panagoulias, Anastasios. (2017). Panagoulias Anastasios DESIGN AND DEVELOPMENT OF A MOBILE DATA AGGREGATION PLATFORM FOR WIRELESS INTRABODY SENSOR NETWORK IN THE MEDICAL FIELD. 10.13140/RG.2.2.31267.04643.

Raspberrypi.org. (2019). [online] Available at: https://www.raspberrypi.org/products/raspberry-pi-3-model-b/

Professionalqa.com. (2019). *Big bang SDLC model| Professionalqa.com*. [online] Available at: https://www.professionalqa.com/big-bang-sdlc-model

Soleymani, M., Chanel, G., Kierkels, J. and Pun, T. (2009). Affective Characterization of Movie Scenes based on Content Analysis and Physiological Changes. *International Journal of Semantic Computing*, 03(02), pp.235-254.

Tutorialspoint.com. (n.d.). *SDLC - Agile Model - Tutorialspoint*. [online] Available at: https://www.tutorialspoint.com/sdlc/sdlc_agile_model.htm

Zhou, L., Blackley, S., Kowalski, L., Doan, R., Acker, W., Landman, A., Kontrient, E., Mack, D., Meteer, M., Bates, D. and Goss, F. (2018). Analysis of Errors in Dictated Clinical Documents Assisted by Speech Recognition Software and Professional Transcriptionists. *JAMA Network Open*, 1(3), p.e180530.

FINAL YEAR PROJECT WEEKLY REPORT

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Faculty of Information and Communication Technology (Kampar Campus), UTAR.

FINAL YEAR PROJECT WEEKLY REPORT 1

(Project I I)

Trimester, Year: Y3S3	**Study week no.: Week 2**
Student Name & ID: Chong Yi Xuan 16ACB04102	
Supervisor: Dr. Goh Hock Guan	
Project Title: Voice Controlled Mobile Embedded Device	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

In these 2 weeks, I have defined the system implementation. Besides that, I have also started to craft the Alexa Skills Library using the lambda function provided by Alexa Skills Kit. Other than this, I have also started to craft the Flask server program to handle the HTTP request.

2. WORK TO BE DONE

Work to be done on next 2 weeks are continuing to craft Alexa Skills Library and Flask server program.

3. PROBLEMS ENCOUNTERED

No problem encountered in these 2 weeks

4. SELF EVALUATION OF THE PROGRESS

All the scheduled tasks are in good progress.

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT 2

(Project I I)

Trimester, Year: Y3S3	**Study week no.: Week 4**
Student Name & ID: Chong Yi Xuan 16ACB04102	
Supervisor: Dr. Goh Hock Guan	
Project Title: Voice Controlled Mobile Embedded Device	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

In these 2 weeks, I am continuing to craft the Alexa Skills Library using the lambda function provided by Alexa Skills Kit. Other than this, I am also continuing to craft the Flask server program to handle the HTTP request.

2. WORK TO BE DONE

Work to be done on next 2 weeks are continuing to craft Alexa Skills Library and Flask server program.

3. PROBLEMS ENCOUNTERED

No problem encountered in these 2 weeks.

4. SELF EVALUATION OF THE PROGRESS

All the scheduled tasks are in good progress.

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT 3

(Project I I)

Trimester, Year: Y3S3	**Study week no.: Week 6**
Student Name & ID: Chong Yi Xuan 16ACB04102	
Supervisor: Dr. Goh Hock Guan	
Project Title: Voice Controlled Mobile Embedded Device	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

In these 2 weeks, I am continuing to craft the Alexa Skills Library using the lambda function provided by Alexa Skills Kit. Other than this, I am also continuing to craft the Flask server program to handle the HTTP request.

2. WORK TO BE DONE

Work to be done on next 2 weeks are continuing to craft Alexa Skills Library and Flask server program.

3. PROBLEMS ENCOUNTERED

No problem encountered in these 2 weeks.

4. SELF EVALUATION OF THE PROGRESS

All the scheduled tasks are in good progress.

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT 4

(Project I I)

Trimester, Year: Y3S3	**Study week no.: Week 8**
Student Name & ID: Chong Yi Xuan 16ACB04102	
Supervisor: Dr. Goh Hock Guan	
Project Title: Voice Controlled Mobile Embedded Device	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

In these 2 weeks, I am continuing to craft the Alexa Skills Library using the lambda function provided by Alexa Skills Kit. Other than this, I am also continuing to craft the Flask server program to handle the HTTP request.

2. WORK TO BE DONE

Work to be done on next 2 weeks are continuing to craft Alexa Skills Library and Flask server program.

3. PROBLEMS ENCOUNTERED

No problem encountered in these 2 weeks.

4. SELF EVALUATION OF THE PROGRESS

All the scheduled tasks are in good progress.

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT 5

(Project I I)

Trimester, Year: Y3S3	**Study week no.: Week 10**
Student Name & ID: Chong Yi Xuan 16ACB04102	
Supervisor: Dr. Goh Hock Guan	
Project Title: Voice Controlled Mobile Embedded Device	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

In these 2 weeks, I am continuing to craft the Alexa Skills Library using the lambda function provided by Alexa Skills Kit. Other than this, I am also continuing to craft the Flask server program to handle the HTTP request.

2. WORK TO BE DONE

Work to be done on next 2 weeks are testing the crafted Alexa Skills and Flask server program.

3. PROBLEMS ENCOUNTERED

No problem encountered in these 2 weeks.

4. SELF EVALUATION OF THE PROGRESS

All the scheduled tasks are in good progress.

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT 6

(Project I I)

Trimester, Year: Y3S3	**Study week no.: Week 12**
Student Name & ID: Chong Yi Xuan 16ACB04102	
Supervisor: Dr. Goh Hock Guan	
Project Title: Voice Controlled Mobile Embedded Device	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

In these 2 weeks, I am continuing to test the crafted Alexa Skills and Flask server program. Besides that, I have also reported the progress with my supervisor.

2. WORK TO BE DONE

Work to be done on next 2 weeks are testing the crafted Alexa Skills and Flask server program. Other than this, documentation is also need to be done.

3. PROBLEMS ENCOUNTERED

AlexaPi service program is not stable.

4. SELF EVALUATION OF THE PROGRESS

All the scheduled tasks are in good progress.

Supervisor's signature

Student's signature

Poster

Voice Controlled Mobile Embedded Device

By: Chong Yi Xuan

Supervisor: Dr Goh Hock Guan

Introduction

Alexabot is a voice controlled robot which consist of GoPiGo3 and Rasberry Pi. This robot is implemented with Amazon's Alexa voice service.

Methods

This project is developed using Big Bang Model

Conclusion

An Alexa based voice controlled robot with the capable of moving, searching online and interact with user is developed.

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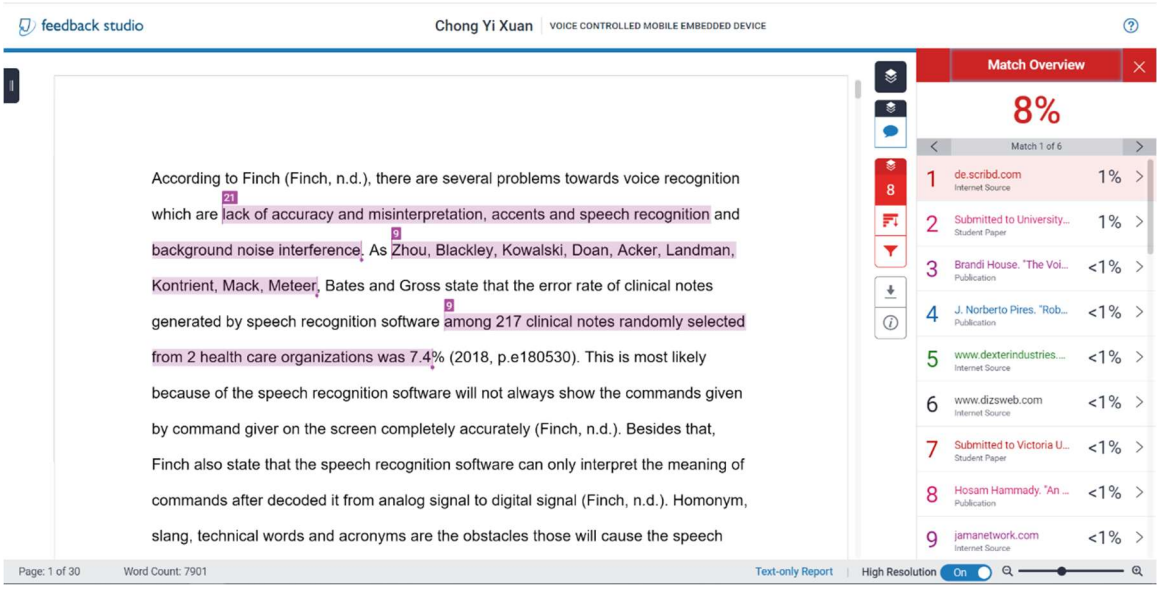
feedback studio
Chong Yi Xuan
VOICE CONTROLLED MOBILE EMBEDDED DEVICE
According to Finch (Finch, n.d.), there are several problems towards voice recognition which are lack of accuracy and misinterpretation, accents and speech recognition and background noise interference. As Zhou, Blackley, Kowalski, Doan, Acker, Landman, Kontrient, Mack, Meteer, Bates and Gross state that the error rate of clinical notes generated by speech recognition software among 217 clinical notes randomly selected from 2 health care organizations was 7.4% (2018, p.e180530). This is most likely because of the speech recognition software will not always show the commands given by command giver on the screen completely accurately (Finch, n.d.). Besides that, Finch also state that the speech recognition software can only interpret the meaning of commands after decoded it from analog signal to digital signal (Finch, n.d.). Homonym, slang, technical words and acronyms are the obstacles those will cause the speech
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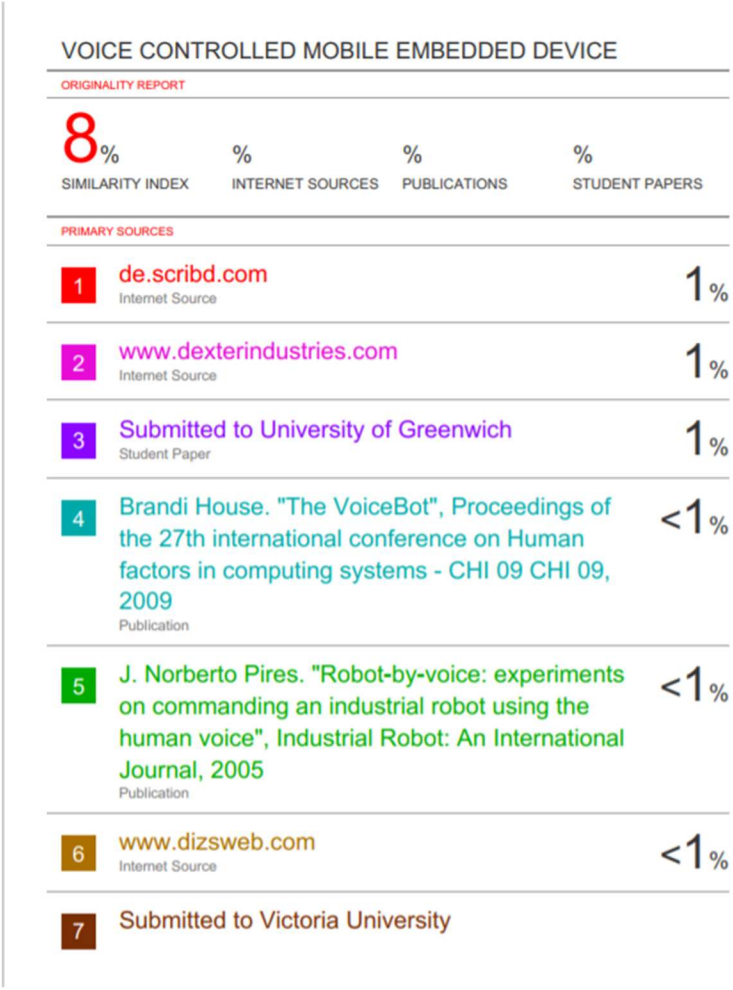
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Based on the above results, I hereby declare that I am satisfied with the originality of the Final Year Project Report submitted by my student(s) as named above.

Signature of Supervisor

Name: Dr. Goh Hock Guan

Date: 18/9/2020

Signature of Co-Supervisor

Name:

Date:

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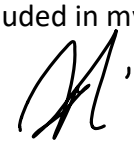
I, the author, have checked and confirmed all the items listed in the table are included in my report.  _____ (Signature of Student) Date: 17 September 2020	Supervisor verification. Report with incorrect format can get 5 mark (1 grade) reduction.  _____ (Signature of Supervisor) Date: 17 September 2020