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Design and Development of a Smart Voice Reminder Device

Shen Yee Pang[1], Jacob Daryl Yuon Ee Lee[1], Tick Hui Oh[1]*

[1] *Faculty of Engineering & Technology,*
Multimedia University, Melaka 75450, MALAYSIA

*Corresponding Author: thoh@mmu.edu.my
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Abstract

During the COVID-19 pandemic period, an average student receives more assignments from their teachers while taking online classes. It can be challenging for these young minds to keep track of every assignment's deadline on top of the various online classes that require their attendance and punctuality. So, to prevent the students from missing any of their online classes and assignment submission, a solution more than just a calendar's reminder is required as many primary school students might not have access to smartphones. Hence, a voice reminder device is proposed in this paper for this purpose. Raspberry Pi 4 is used to build this device, along with a Python-based program to connect it to the Google calendar server. The system's speech recognition is done using a Python speech recognition package. The system uses the Google Cloud Speech API to translate the user's speech input into a text format that the system can understand. The information required to produce the user-specified event is then extracted along with the activation word, all from the user's text. The system then saves the event into Google calendar, using the Google Credentials.json file as its destination file after extracting all the important data. The user can add, edit, or delete any previously established event using the Google calendar from any location as long as the device is online. It can also generate a timetable through voice command. Other notable usage of this device includes keeping elderlies with Alzheimer's disease on track with their important tasks like scheduled medication and medical follow-ups. The prototype managed to achieve a rather high accuracy rate of 85.6% through its speech recognition function.

1. Introduction

The coronavirus, which is also known as the COVID-19 disease, was first identified on November 17, 2019, from an outbreak in Wuhan, China. The symptoms of this unidentified pneumonia include fever, a dry cough, tiredness, loss of taste, smell, and sore throat. Additionally, there are severe cases of COVID-19 people who have chest pain, difficulty speaking, shortness of breath, or paralysis. In late December 2019 at the Huanan Seafood Wholesale Market in Wuhan, Hubei, China, the second outbreak of this recently found virus was reported to have occurred, infecting 66% of the staff there [1]. Because the Chinese government was unable to stop the virus, it quickly spread over the world. The World Health Organization, or WHO as it is more commonly known, officially declared a public health emergency of international concern on January 30, 2020, citing a "public health risk to other States through the international spread of disease and to potentially require a coordinated international response" [2].

The global epidemic will follow on March 11, 2020. As of March 25th, 2022, there have been a total of

478,269,019 incidents reported, resulting in a cumulative fatality toll of 6,133,918 [3]. Since then, the daily lives of all the citizens of every single country have been affected by the global pandemic, and a country-scale lockdown was implemented by the Malaysian government from the 1st of June 2021 until the 28th of June 2021. Since then, people have been working from home and the students had to attend their classes virtually. The transition from physical face-to-face classes between the educator and the students towards online learning has been a difficult process for both students and educators across the world. For many, the new format of the syllabus for their classes has affected their motivation towards learning and a lack of structure with online learning as compared to the traditional classroom [4]. The place where studies are taking place is also one of the major factors that affected the students from staying motivated for online classes as generally a home is a peaceful place where one should feel secure and comfortable and it is also a place for one to recharge themselves after a long tiring day, it is a lot harder for the student to stay motivated on one task without getting sidetracked or distracted from many elements.

According to the research and survey conducted by [5-6], intelligent digital reminder systems can assist people by prompting them to take certain actions in the future while also helping them recall information in a number of contexts. Consumers, regardless of age group, want to be informed of a variety of future responsibilities, according to the poll's authors, who were mentioned. There are new and profitable possibilities when reminder systems are designed to facilitate the generation of reminders, for instance by giving missing details, and making those reminders visible in various places and to various people so that they might become a regular part of a person's or household's routine.

Guerrouat et. al. designed a GPS-based multi-function reminder system targeted at students [7]. This reminder system consists of six reminder components and will remind you of a certain event that will happen at that specific area within a certain radius set by the user. The system will send an alert and a pop-up message on the user's device as soon as they enter the predetermined places detected by GPS. In contrast, our approach is more concerned with using the voice recognition feature to create events on the device than using GPS to trigger them. Another variation, however, this time we are concentrating on informing the user through sending audio messages as opposed to pop-up notifications.

A robotic assistant equipped with speech recognition to create appointments and provide reminders was developed by [8] in Costa Rica. The hardware-software architecture for a robot based on an Arduino Uno and a smartphone running the Android platform. Similar to this project, the goal of this one is to employ speech recognition to let users save event reminders. Their solution, however, is entirely dependent on an Android phone, but we aim to eliminate the mobile phone from the system so that parents or other caretakers can create events from any location as long as they have access to the internet.

Forgetfulness is a significant challenge for patients who do not take their medications in the correct amount on time; it has been discovered that this results in malfunction and reduces the effectiveness of their prescription. In order to solve the issue, a user-friendly Dose Reminder System has been developed [9]. Using a real-time clock, or RTC, the system checks its current operating time with the time the user is supposed to take their medication. When an event is identified, the micro-controller determines the essential canister, and the alert remains "ON" indefinitely until the user arrives at the machine and presses the button located on the device by doing so the alarm will stop alerting the user to take the medication and the pre-set amount of medication will be dispensed out of the device and the device will dispense a half cup full of mineral water for the user to consume their medication. The proposed system is yet to have a GSM or WIFI module, so it will be troublesome to update if there is any new medicine added to patients or a change of medication time.

On the other hand, a medical-based reminder system was proposed in Taiwan in which the main components used for the whole project are the Arduino board, Bluetooth module, and the switch LCD circuit [10]. The system sets administrative dosage by QR code on pharmacist instructions. Reminder re-order timing through the apps and prompts the user through text or voice message. The hint messages will be sent to the user once it's time for the pre-set dose to be taken and a graphic icon will be displayed to allow the user to easily identify the type of medication. The switch's opening time is timed and compared after use to confirm the occurrences. After that, the apps started sending daily reports to family members. However, it was not mentioned if a voice message is working and whether the system must work together with a smartphone. Similar work is also presented in [11], where QR code can be generated in two places, e-Health system automatically by creating a prescription or once the pharmacy issues the medicament to the patient.

In today's fast-paced environment, people commonly struggle to keep track of their daily responsibilities and commitments. Traditional reminder methods, such as writing them down on paper or setting alarms on our phones, can be ineffective and easily forgotten. However, with the advancement of technology, a new alternative has emerged: the voice recognition reminder system. This system uses cutting-edge voice recognition technology to properly perceive and interpret user requests, allowing consumers to generate reminders and manage their calendars with ease. This article will look at the main features and capabilities of a voice recognition reminder

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system, as well as how it is created and implemented. It will also go through the potential benefits of such a system, such as increased productivity and improved time management.

2. Prototype Design Overview

Fig.1 shows the overall flow of the program. The program starts by recognizing speech input from the user, followed by speech-to-text conversion, keyboard extraction and lastly saving the event in Google calendar. The entire project is based on Python language for its software side and Raspberry Pi 4 is the main hardware in this project. At the same time, the voice recognition and keyword extraction process are using artificial intelligence as its core.

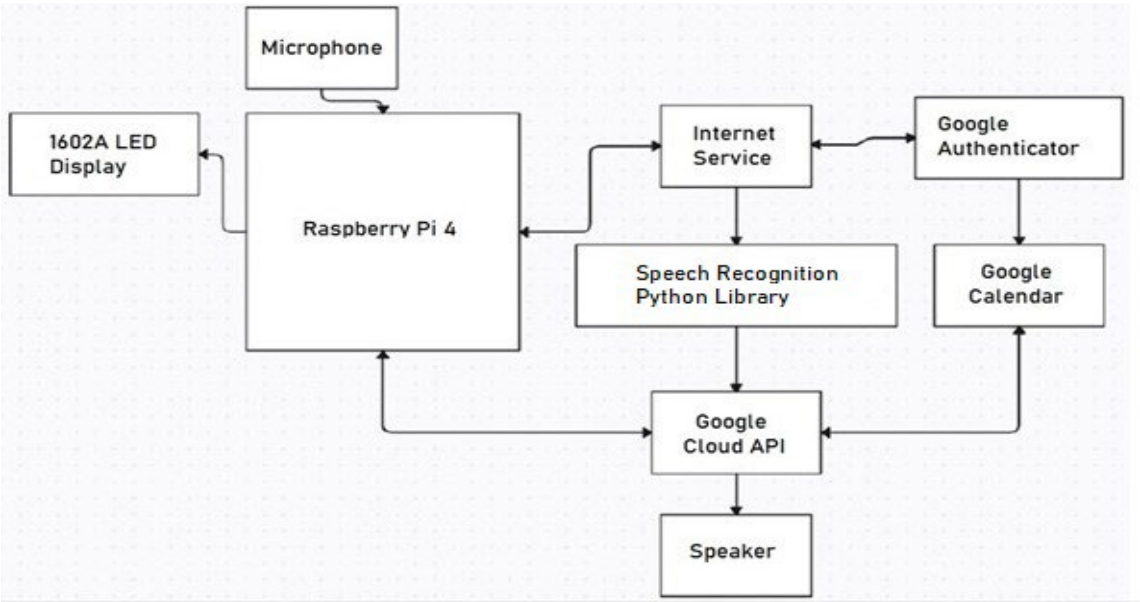

Fig. 1 *Block diagram of the system*

2.1 Hardware Development

Raspberry Pi 4 is a popular single-board computer that is widely used for a variety of applications, such as robotics, home automation, and education. There are several reasons why Raspberry Pi 4 is considered better than its predecessors and other competing single-board computers. Raspberry Pi 4 features a quad-core ARM Cortex-A72 processor, which provides a significant performance improvement compared to the previous models. This means that it can handle more demanding applications and tasks with ease. The Raspberry Pi 4 comes with up to 8GB of RAM, which is a considerable improvement over the previous models. This allows for faster data processing and multitasking, making it ideal for more complex projects. The Raspberry Pi 4 includes dual-band 802.11ac wireless connectivity and Bluetooth 5.0, providing faster and more reliable wireless communication. It also has two USB 3.0 ports and two USB 2.0 ports, making it easier to connect external devices. Raspberry Pi 4 includes hardware decoding for 4K video playback and supports multiple displays. This makes it ideal for multimedia applications, such as media centers and gaming consoles. Despite its increased performance, Raspberry Pi 4 is still energy-efficient, consuming less power compared to similar devices. This makes it an excellent choice for battery-powered projects and IoT applications. Overall, the Raspberry Pi 4 is an impressive improvement over its predecessors, providing increased performance, improved connectivity, and better multimedia support. It's a versatile device that can be used for a variety of projects, making it an excellent choice.

Google speech API is a widely used speech recognition library which is a cloud-based system that is used for Python programming. Voice inquiries and 37 instructions are communicated to the different instruments and devices in the recognized form after being recognized by the cloud service. This system's working model is comparable to Siri's working model, which is the speech recognition software used in Apple devices [12]. Fig. 2 shows the overall flow of the program. The program starts by recognizing speech input from the user, followed by speech-to-text conversion, keyboard extraction and lastly saving the event in Google calendar. The entire project is running based on Python language for its software side of the project and the hardware that we used for this project is a Raspberry Pi 4 with a microphone. The process of voice recognition and keyword extraction will use artificial intelligence as its core.

2.2 Voice Recognition

Voice recognition, also known as speech recognition, is a technology that enables computers to recognize and interpret human speech. It involves using algorithms and machine learning to analyze and interpret the sounds and patterns in spoken language, allowing a computer system to understand and respond to voice commands or transcribe spoken words into text. The process of voice recognition involves several steps, including signal processing, feature extraction, acoustic modeling, and language modeling. During signal processing, the sound waves from the user's voice are recorded and transformed into a digital signal that can be analyzed by the computer. Feature extraction involves identifying and extracting relevant acoustic features, such as pitch, duration, and intensity, from the digital signal.

Acoustic modeling involves creating a statistical model of the speech sounds based on the extracted features, which is used to identify the words and phrases spoken by the user. Finally, language modeling involves analyzing the context and structure of the spoken words to interpret their meaning and respond appropriately. Voice recognition technology is used in a wide range of applications, from virtual assistants like Siri and Alexa to speech-to-text software used for dictation and transcription. It can improve the accessibility of technology for individuals with disabilities, such as those with visual impairments or physical disabilities that make it difficult to use a keyboard. Additionally, voice recognition can enhance the convenience and efficiency of human-computer interaction, enabling users to perform tasks hands-free and with greater speed and accuracy.

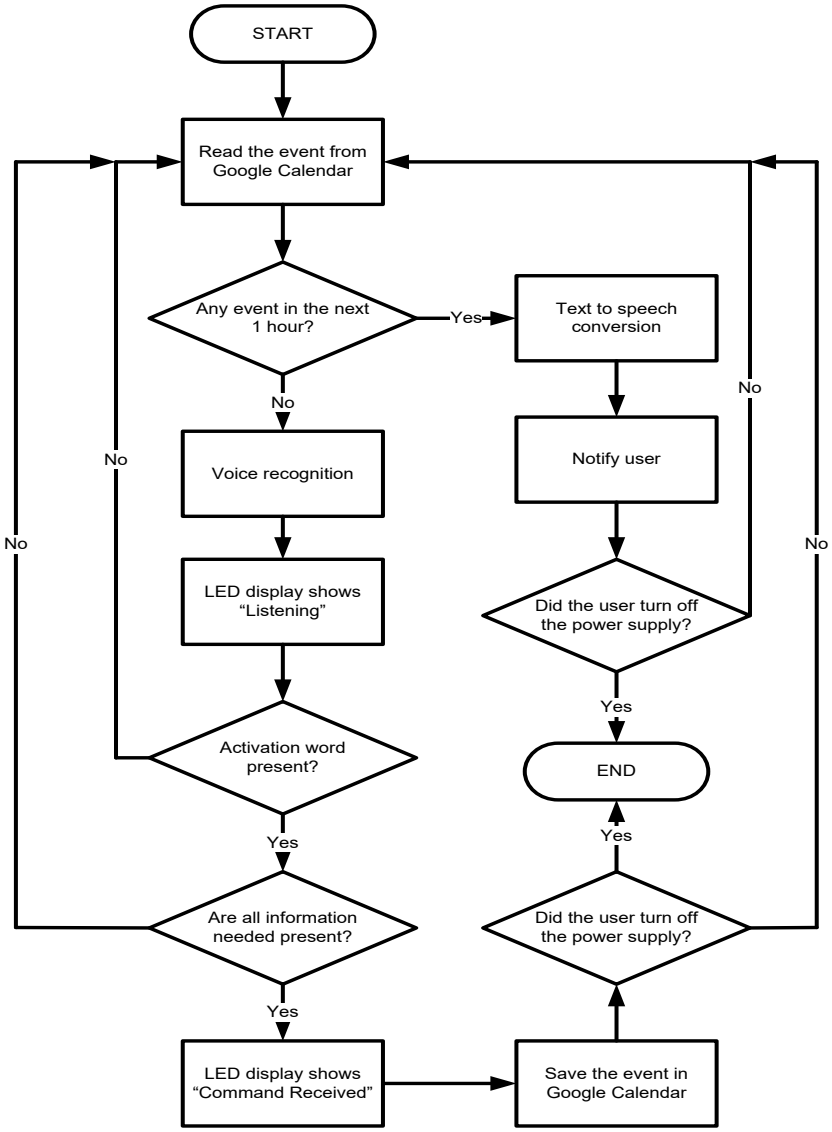

Fig. 2 *Flow chart of the system*

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2.3 Voice Activation

An activation word, also known as a wake word, is a specific word or phrase that is used to activate a voice-activated device or system. When a user speaks the activation word, the device or system begins listening for further voice commands or requests. For example, on a smartphone, the activation word might be "Hey Siri" or "OK Google" while this project activation word is “Honeybee”. When the user says the activation word, the device activates its voice assistant and waits for further commands or queries. Activation words are used in voice-activated devices and systems to prevent them from constantly listening to and processing all ambient sounds. Instead, they only activate and listen when the user intentionally speaks the activation word, saving power and processing resources. Activation words are typically chosen to be distinct and easy to recognize, even in noisy environments. They are often designed to be natural and intuitive to say, making it easier for users to interact with voice-activated systems. Additionally, many voice-activated devices allow users to customize the activation word to better fit their preferences and habits. If the activation word is not being mentioned, then the program will loop itself and continue to listen to the user’s command until the activation word “honeybee” is mentioned by the user.

2.4 Speech to Text

Speech-to-text, also known as automatic speech recognition (ASR), is the process of transcribing spoken language into written text. Python offers several libraries and modules that can be used for speech-to-text transcription. One of the most popular libraries for speech-to-text transcription in Python is the SpeechRecognition library. This library supports multiple speech recognition engines, including Google Speech Recognition, Sphinx, and Wit.ai. It provides a simple interface for capturing audio from various sources, such as microphones and audio files, and transcribing speech into text. For this function to work, the Google Cloud Speech API is used.

2.5 Information Extraction

Right after the user gives the command with the activation word, the program will then process the voice commands given by the user to extract the date, time, and event name so that the program can save it into the calendar. The date is a tricky one as the user may say the actual date like the 5th of January which will make things easier but that is not always the case, sometimes the user will say tomorrow, this Friday, or even next Monday. So, the program must be able to identify the keyword for the date and be able to save the event on the correct date.

As for the time the user will sometimes say 5:30 pm or 1 am so the program will need to be able to identify the work “morning”, “evening”, “afternoon” and “night” and based on that the program will save the event under the time given by the user. As for the event name, the program should be able to automatically remove the front part of the command which is used to activate the program. For example, if the user gives commands like “Honeybee, remind me tomorrow I have science class at 5 pm.” The program should save the event as “Science Class” at 5 pm the next day the user gives the command.

2.6 Saving the Event

There are many approaches for this part as we can choose between creating our calendar in which the program will have its local calendar that can only be accessed either by the user via voice command or connected to a monitor, mouse, and keyboard or we have to create a dedicated mobile application so that the parents can view what are the events that will happen soon and they can add or delete or even edit the event. This will take a lot of time and the parents will only be able to access the calendar when the mobile phone is in close proximity to the Raspberry Pi 4.

Due to the limitation that will be faced if the local calendar approach is being used, the Google calendar approach seems more reasonable for this project as the parents can check and edit or even add events to the Google calendar that is connected to the Raspberry Pi 4 wherever they are as long as they have access to the internet. The downside of using the Google calendar is that the Raspberry Pi 4 must be connected to the Internet for it to work. Without Internet access, the program will not be able to save the event in the Google calendar. For us to access the Google calendar, we also need to have a file name credentials.json which allows us to key in our usernames and passwords so that we can access the Google calendar for that specific account.

2.7 Reading the Event

The program will constantly read if there is any event that will happen within one hour from the time the program is reading the Google calendar. When the program detects that there will be an event that will happen soon, the program will then extract the information from the Google calendar like the name of the event and then it will convert the text of the event name into speech so that the Raspberry Pi 4 will tell the user that the specific event will happen within an hour by using the Google text to speech function. From there the program will then notify the user through devices that are connected to the 3.5mm headphone jack.

2.8 Displaying Current Operation

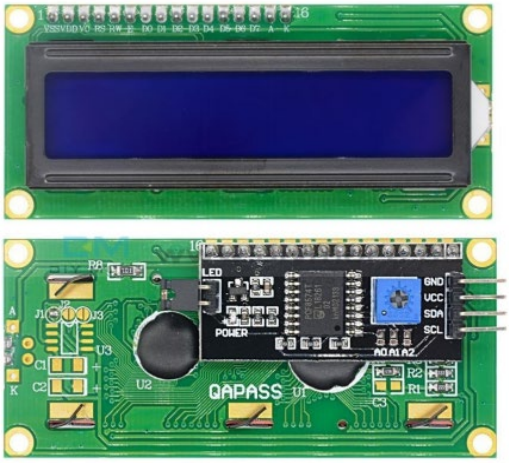

Fig. 3 *1602A LCD display with I2C module*

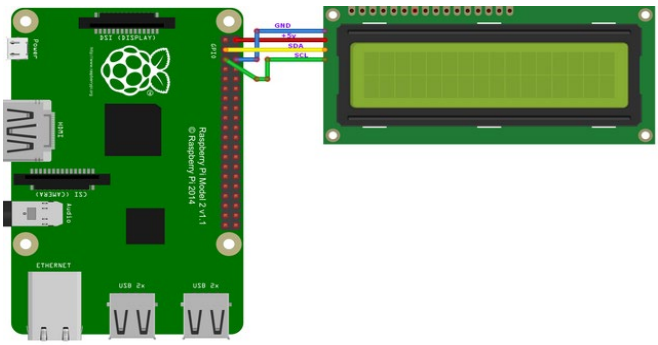

Fig. 4 *Connections of the 1602A with I2C to Raspberry Pi 4*

Fig. 3 shows the 1602A LCD display with the I2C Module that is used to display the current operation of the device. The 1602A is a commonly used character LCD display that can display two lines of 16 characters each. It is popular in embedded systems and microcontroller projects and can be easily interfaced with an I2C module to simplify the wiring and control of the display. The I2C module, also known as an I2C backpack, is an add-on board that interfaces between the 1602A display and the microcontroller. It uses the I2C protocol to communicate with the microcontroller, reducing the number of required pins and simplifying the wiring.

Fig. 4 shows the connection between the 1602A with I2C and the Raspberry Pi 4. The GND pin of the LCD display will connect to pin 6 of the Raspberry Pi 4 while the SDA and SCL will connect to pin 3 and pin 5 respectively. Lastly, the VCC pin of the I2C will be connected to the 5V power supply of the Raspberry Pi 4 which can be either pin 2 or pin 4.

3. Results and Discussions

3.1 Speech Recognition

There are multiple approaches when it comes to voice recognition and each approach has its pros and cons. There are *apia*i which focus more on the natural language processing of the user and are mostly used for identifying the speaker's intent which generally goes beyond basic speech recognition. There is also another approach instead of using *apiai* which is the Google Cloud Speech API also known as Application Programming Interface in which we could integrate Google speech recognition software into our project through their cloud server and link our data with their voice recognition cloud server.

As English is a widely used language that can be considered the go-to language when it comes to communication on terms at the international level, it is not very uncommon for each country to have an accent when it comes to the English language. It can be challenging for the program to recognize the same word for different accents. Google Cloud Speech API generally has accurate speech recognition for each accent that the user has but the downside of Google Cloud Speech API is that it is a subscription-based service that we need to pay to access their services. Other than Google Cloud Speech API, there is another approach that does not require any

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subscription and it's easy to use the SpeechRecognition API Python library. The good thing about SpeechRecognition API is that it comes together with a FLAC encoder which we can run our code on Windows, Mac OS, Linux, and Raspberry Pi OS.

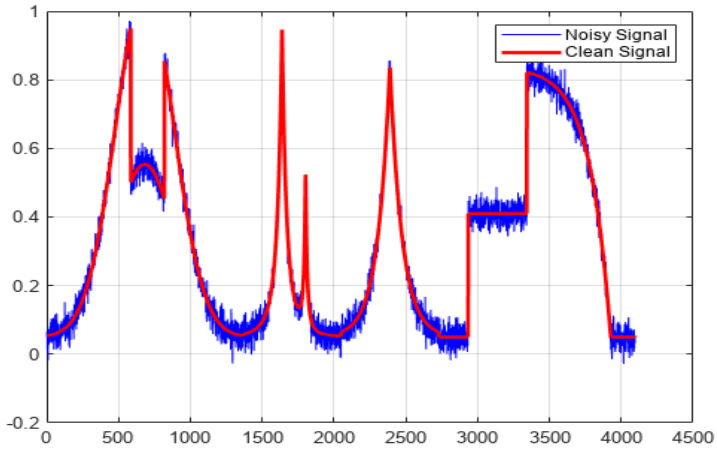


Fig. 5 *Denoising noise wave signal*

The waveform in Fig. 5 shows the denoising of a noise wave signal. Before the audio is transmitted to the speech-to-text process, the program will first adjust the ambient voice so that the user's voice command is received loud and clear and will not get affected by the ambient noise of the user as in real-world applications it is impossible for the user to always have a quiet and peaceful environment and ambient noise is one of the major factors that will cause any distortion in the voice commands given by the user. Adjusting ambient noise is one of the functions of the SpeechRecognition API package.

3.2 Activation Word

A certain condition must be satisfied for the program to know whether it is a voice command from the user or the user is having a conversation with an acquaintance that involves date and time. Hence, an activation word is the best option for us to let the program know that it is a voice command given by the user instead of the user having a conversation in front of the devices. The concept of activation word is not something new as major corporations are also using this same method for their flagship product, for example, Apple Inc. an American multinational technology company uses the phrase "Hey Siri" to activate their voice assistant function named "Siri" for all their products that have that voice assistant features and Google LLC an American multinational technology company uses "Okay Google" or "Hey Google" for their products that have access to their voice assistant functions. The way this activation word is implemented into the project is that from the text received right after the Speech to text process, an if-else condition is set.

When the program detects the activation word "honeybee" or "honeybee" the program will register it as a voice command, and it will start its information extraction process. There are two conditions for the activation word sometimes the program will recognize it as "honeybee" which is the activation word without spacing and sometimes it will register it as "honeybee" which is the activation word that comes with a space in the middle. It depends on how fast the user pronounces the activation word and how the user pronounces the activation word. After much consideration, implementation of both conditions is a better choice as it is the same word just with a different format just like how Google LLC implemented their voice assistant.

3.3 Information Extraction

Information Extraction is one of the hardest parts of the entire project. For the information extraction to work, identifying the required information that needs to be included in the code is important. The title of this project is "Voice Recognition Reminder System." The required information that will be used by the user is generally the date of the event, the time of the event, and the purpose of the event, which is also called the name of the event. We will need to go through each required information and make sure that the code can extract the correct information based on the voice command given by the user. The extraction of the date information is recorded in Table 1 and the results of the event created are shown in Table 2.

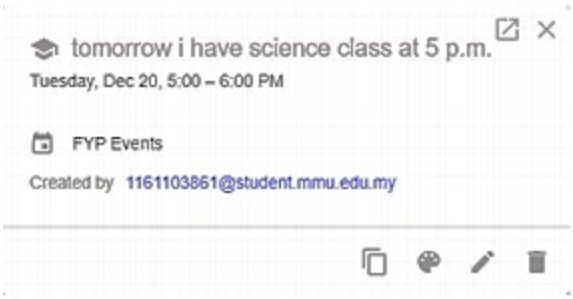
As we can see it will remove the "honeybee remind me" and retain the remaining information and save it as the name of the event in Google calendar. The ideal output is supposed to be only the event name excluding the time and date of the event but due to the different sentence structure that the user will provide when giving out

voice commands, it is very hard to make sure that the program will only extract the name of the event and remove the date and time of the event created.

Table 1 *Results of date extraction*

Types of date information given by users (assuming voice commands are given on 13/10/2022 Thursday)	What is registered in the program
"tomorrow"	14/10/2022
"this Sunday"	16/10/2022
"this coming Tuesday"	18/10/2022
"next Monday"	17/10/2022
"3rd of November"	3/11/2022

Table 2 *Results of event creation*

Voice command from the user	Title of the event created in Google calendar
" honeybee, remind me tomorrow I have science class at 5 pm."	

3.4 Information Display

Once the user gives a voice command, the program will extract all the information needed from the voice command given by the user. If the information that is needed to create an event is not present, the LCD panel will display "I do not understand the statement" and when all the information is present, the LCD panel will display "Command received" to notify the user that the program understood the voice command given by the user and the event stated by the user had been created in the Google calendar. Fig. 6(a)-(d) show some of the LCD displays at different commands.

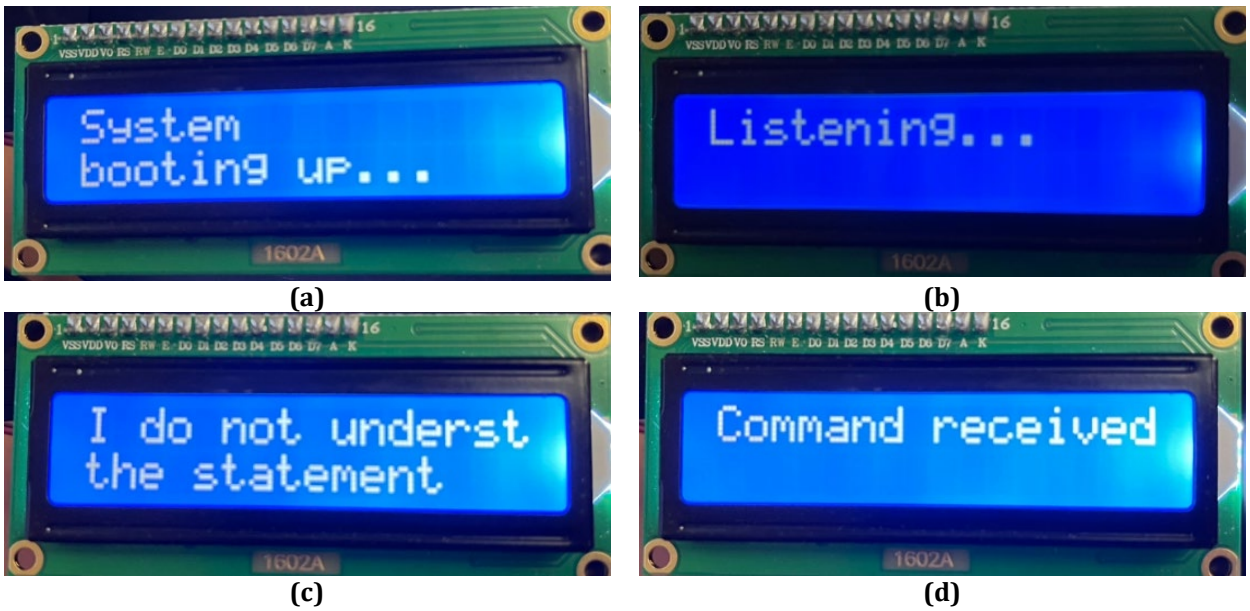


Fig. 6 *Some of the LCD panel displays at different commands*

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3.5 Experimental Results

Table 3 Functionality test by 20 participants

Name	Age	Results				
Mior Adam	62	PASS	PASS	PASS	PASS	PASS
Anthea Jayne	22	FAIL	PASS	FAIL	FAIL	PASS
Farah Umierah	23	PASS	PASS	PASS	PASS	PASS
Amira Zulaikha	23	PASS	PASS	PASS	PASS	PASS
Jacob Lee	23	PASS	PASS	PASS	PASS	PASS
Lau Shun Ze	23	FAIL	PASS	PASS	PASS	PASS
Alep	46	PASS	PASS	PASS	PASS	PASS
Marcuan	44	FAIL	PASS	PASS	PASS	PASS
Ash	62	PASS	PASS	PASS	PASS	PASS
Qish	35	PASS	FAIL	PASS	PASS	PASS
Margeret Tai	70	FAIL	PASS	FAIL	PASS	PASS
Nizar	37	PASS	PASS	PASS	PASS	PASS
Sandrina Cristy	22	FAIL	PASS	PASS	PASS	PASS
Josh	22	FAIL	FAIL	PASS	PASS	PASS
Irish Sultan	22	PASS	PASS	PASS	PASS	FAIL
Maricel	23	PASS	PASS	PASS	PASS	FAIL
Vanessa	23	PASS	PASS	PASS	PASS	PASS
Nikeisha	22	PASS	PASS	PASS	PASS	PASS
Aqim	38	FAIL	PASS	PASS	PASS	FAIL
Shamita	22	PASS	PASS	PASS	PASS	PASS
Gan	45	PASS	FAIL	PASS	PASS	PASS
Anson	46	PASS	PASS	PASS	PASS	PASS
Desmond	40	PASS	PASS	PASS	PASS	FAIL
Yohji	50	PASS	PASS	PASS	PASS	PASS
Julie	35	PASS	FAIL	PASS	PASS	PASS

In order to test the program's functionality, an experiment was conducted whereby people were invited to say the exact same word and see if the program can detect what voice commands are they saying and see whether the program can detect different English accents. The test subject is mostly in their 20s with 4 adults in their 30's, 5 adults in their 40's, and 2 in their 60's. The sentence that the test subject will be saying is "Honeybee remind me I have an event this coming Monday at 3 pm." for 5 times.

The 25 participants are asked to repeat the same command 5 times and the results as tabulated in Table 3, show that out of the 125 attempts, 107 passed the test which means an accuracy of 85.6%. Hence, the accuracy of the voice recognition function of the program is 85.6% which is considered highly efficient.

4. Conclusion

A reminder device prototype with voice recognition capability is successfully designed and built in this project with a rather high accuracy rate of 85.6%. The prototype is capable of announcing upcoming events and users can add, edit, or delete events quickly simply through Google calendar while on the go. Future possible enhancements such as fall detection, GPS, and SOS alerts can be incorporated into the device. Higher accuracy can be achieved by testing the system with other sentences and more repetitions, which will be done in future works. Other possibilities that are worth exploring will include integrating some artificial intelligence elements into the system, such as machine learning, to make it more versatile and user-friendly.

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Conflict of Interest

Authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm their contribution to the paper as follows: ***Project concept and design:*** *S.Y.Pang, Y.E.L. Jacob Daryl;* ***data collection:*** *Jacob;* ***data analysis and interpretation of results:*** *T.H. Oh, Y.E.L. Jacob Daryl;* ***draft manuscript preparation:*** *T.H. Oh, S.Y. Pang. All authors have reviewed the results and approved the final version of the manuscript.*

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