The 6th International Conference on Information Technology (InCIT 2022)

10th-11th NOVEMBER 2022

@PANYAPIWAT INSTITUTE OF MANAGEMENT (PIM)
NONTHABURI, THAILAND

MESSAGE FROM GENERAL CHAIR

On behalf of the CITT Association, it is our great honor to welcome you to the 6th International Conference on Information Technology (InCIT 2022) at Panyapiwat Institute of Management (PIM) in Nonthaburi, Thailand.

InCIT is an essential forum for researchers to discuss the state-of-the-art and future trends of related technology and exchange experiences. Hence, we encourage delegates to participate actively in the sessions and discussions ahead during the conference days.

On behalf of the CITT Association, we would like to thank the international coordinators, advisory committees, organizing committees, program chairs, and reviewers who voluntarily invested their time in selecting papers and arranging such a successful conference. We wish everyone a happy time with this successful and fruitful conference and enjoy their stay in Thailand.

We would like to express our gratitude to all committee members for their devotion and hard work to make this truly successful conference. Finally, we wish you all the inspiriting discussions and enjoy your time along with cordial and sincere friendship at InCIT2022, Thailand.

Thank you very much.

Assoc.Prof. Pisit Charnkeitkong , D.Eng.

InCIT2022 General Chair

President of CITT Association

Panyapiwat Institute of Management

MESSAGE FROM TECHNICAL PROGRAM CHAIR

On behalf of the technical program committee (TPC), we would like to deeply thank all participants and it is our great pleasure to welcome you to the 6th International Conference on Information Technology (InCIT 2022).

We are very excited about the technical program that brings together many high-quality papers from many countries, more than hundred contributed papers that were submitted to our conference in this year. Our team which consists of TPCs and reviewers has worked hard to complete the process of peer review and selection. Each paper received comments from the respective research community. In addition, there are three keynote and three invited speakers who contribute in this conference. Consequently, the conference program has about hundred papers from various universities and institutions including both onsite and online sessions.

Finally, we would also like to express our deepest gratitude to all committee members and session chairs who voluntarily invest their own time in selecting papers and arranging such a successful and memorable conference. We hope you enjoy the technical program and that while at the conference you can take advantage of the excellent chance to exchange ideas with other researchers and practitioners, and also initiate some fruitful collaboration between universities or institutions. Welcome you all to PIM, Thailand.

Thank you very much.

Datchakorn Tancharoen, Ph.D.

Technical Program Chair

Panyapiwat Institute of Management

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WELCOME TO InCIT 2022

The 6th International Conference on Information Technology (InCIT2022)

Theme: Digital Technology and Innovation During Education Transformation

Date: 10th-11th November 2022

Venue: Panyapiwat Institute of Management (PIM), Nonthaburi, Thailand

The Sixth International Conference on Information Technology (InCIT2022) is a premier forum for sharing research in areas related to information and communication technologies. We believe that fostering research encompassing intelligent technology and innovation for the future of society is vital. Authors involved in those research areas are cordially invited to submit papers and present them at InCIT2022. The conference will be an ideal opportunity to strengthen collaboration between researchers. It will provide many excellent opportunities for participants to exchange and discuss new innovative ideas and research results, as well as enabling exploration of future directions for cooperative research.

Scope:

- Artificial Intelligence
- Cloud Service and Computing
- Computer Animation and Game
- Database Technology
- Geo-informatics
- IT in Education
- IT Security and Privacy
- Intelligence Communications
- Network Security and Privacy
- Pattern Recognition
- Quantum Computing
- Natural Language Processing
- Smart and Expert Systems
- Wireless and Mobile Networks
- Data Science and Analytics
- Communications and Networking
- Digital Multimedia Technology
- E-Commerce, E-Education, E-Industry, E-Society
- Human Computer Interaction
- IT and Project Management
- IT and Mobile Application
- Internet of Things
- Augmented and Virtual Reality
- Platform Technologies
- Signal Processing
- Bio-medical Informatics
- Web and Internet Technologies
- Other Related Topic

Paper Submission

Full paper submission in English is expected. All manuscripts must be prepared in the standard IEEE Conference Proceedings format and limited to 4-6 pages of A4 form in PDF format. Please use 10 points and Time New Roman font. The authors' names and affiliations, postal addresses, telephones, fax numbers and e-mail addresses must be omitted from the submitted manuscripts. Each manuscript must contain an abstract of about 150 words.

Program Agenda

There are 18 sessions for InCIT2022 delivered by hundreds of national and international speakers. The accepted papers for the conference will be presented as oral presentations on either online or onsite platforms. Both presentations are vital to the success of the conference and are expected to be of similarly high technical quality.

Onsite and Online Oral Presentations

The presenting author or representative must be registered at the Conference and available to provide details and answer questions during the Conference. The presentation has a 12-minute talk by the registered author, followed by a 3-minute discussion period for in-person attendees.

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PROGRAM

InCIT 2022 Program Schedule
10th November 2022

	Period	Program	Location
10 Nov. 2022	8:00-9:00	Registration	CP ALL Academy
	9:00-9:45	Opening Ceremony - Main room (Hybrid)	Auditorium
	9:45-10.15	Keynote I: Dr.Siwaruk Siwamogsatham Secretary- General of Personal Data Protection Committee	
	10:15-10:30	Break	
	10:30-11:00	Keynote II: Dr.Chawapol Jariyawiroj President, Huawei Technologies Thailand Co.,Ltd.	
	11:00-11:30	Keynote III: Assoc. Prof. Dr.Supavadee Aramvith Vice Chair, IEEE Thailand Section	
	11:30-12:00	Program Introduction	
	12:00-13:00	Lunch Break	Hall 1-2

InCIT 2022 Program Schedule
10th November 2022

	Period	Program				Location
10 Nov. 2022	12:00-13:00	Lunch Break				Hall 1-2
	13:00-14:30	Hall 3 - Main room (Hybrid)		Hall 5	Hall 6	PIM Convention Hall
		Invited Speakers		RS1	NCIT1	
		Wu-Yuin Hwang Kwang-Hyun Baek Mitsunori Makino		1570843100 1570825805 1570835232 1570835492 1570822745 1570852119	2335 2977 3836 3971 9730 244	
	14:30-15:00	Break				Hall 1-2
	15:00-16:30	Hall 3	Hall 4	Hall 5	Hall 6	PIM Convention Hall
		IS1	IS2	RS2	NCIT2	
		1570843075 1570835863 1570844613 1570846052 1570822744	1570847124 1570847126 1570842902 1570834778 1570836548	1570845157 1570824071 1570824721 1570835493 1570835385 1570835543	2030 4379 4997 5645 8329 1127	
	16:30-17:30	Networking and Activity				Hall 1-2
	17:30-18:00	Transfer Venue				PIM
	18:00-21:00	Welcome Reception				Best Western Hotel

InCIT 2022 Program Schedule
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	Period	Program				Location
11 Nov. 2022	12:00-13:00	Registration				Hall 1-2
	15:00-16:30	Hall 3	Hall 4	Hall 5	Hall 6	PIM Convention Hall
		SS1	SS2	RS3	NCIT3	
		1570833382	1570836024	1570835562	3510	
		1570844710	1570836075	1570833366	7059	
		1570844721	1570845850	1570835530	8098	
		1570846273	1570845874	1570835752	9249	
		1570821545	1570846151	1570835577	1851	
		1570835724	1570852795	1570835641		
	10:00-10:30	Break				Hall 1-2
	10:30-12:00	Hall 3	Hall 4	Hall 5	Hall 6	PIM Convention Hall
		IS3	SS3	RS4	NCIT4	
		1570845658	1570837890	1570831874	4193	
		1570845219	1570840911	1570845333	5871	
		1570845014	1570846169	1570846110	6559	
		1570845587	1570846224	1570806076	7330	
		1570844962	1570846255	1570846217	7476	
		1570845417	1570848059	1570845922	9309	
	12:00-13:00	Lunch / Online Registration				Hall 1-2

InCIT 2022 Program Schedule
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	Period	Program				Location
11 Nov. 2022	12:00-13:00	Lunch / Online Registration				Hall 1-2
	13:00-14:30	IS4 OL	SS4 OL	RS5 OL	RS6 OL	Online
		1570844878	1570830764	1570822758	1570846202	
		1570843390	1570839344	1570825500	1570830431	
		1570833512	1570830441	1570826043	1570845580	
		1570846510	1570837340	1570835527	1570845032	
		1570844954	1570833679	1570835140	1570847731	
			1570837190			
			1570829885			
			1570826676			
	14:30-15:00	Online Networking – Main room				Online
	15:00-16:30	IS5 OL	SS5 OL	RS7 OL	RS8 OL	Online
		1570845949	1570849084	1570844973	1570852129	
		1570840929	1570843575	1570835342	1570852148	
		1570840931	1570849406	1570835557	1570852154	
		1570841097	1570845068	1570835921	1570852380	
		1570843309	1570852069	1570844864		
	16:30-17:00	Closing Remark - Main room				Online

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Arduino, Raspberry Pi, and Smartphone Usage Comparison for Voice-based Virtual Assistant

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Abstract—**A virtual assistant or an artificial intelligence chatbot is one of the technological interventions to help individuals with borderline personality disorder (BPD). The virtual assistant must have a bank of knowledge to answer the questions from individuals with BPD to accompany and chat with them like a digital friend. As part of artificial intelligence software, Program-O can handle the interaction between users and the bank of knowledge in the server. The voice recognition and text-to-speech features can be used to enhance the virtual assistant's function to become even closer as a friend. There are three possibilities for implementing voice recognition and text-to-speech features on virtual assistants, which are using Arduino, Raspberry Pi, and smartphone devices. All these three devices can be connected to the speech recognition module or Application Protocol Interface (API) for voice recognition on the internet. This paper will explore and compare several aspects of the implementation of voice recognition and text-to-speech features in the virtual assistant. The result will be a recommendation for the application of voice recognition and text-to-speech features on a virtual assistant for individuals with BPD.**

Keywords- borderline personality disorder; chatbot; digital friend; text to speech; virtual assistant, voice recognition

I. INTRODUCTION

Individuals with borderline personality disorder (BPD) have a high risk of suicide. In previous studies [1], 9-33% of suicides were committed by individuals with BPD. There is no single most effective and sustainable approach to prevent them from committing suicide [2]. However, accompanying them will create opportunities to make them more stable, less hopeless, and less alone.

Creating a digital friend such as a virtual assistant with artificial intelligence and the ability to respond to them when they need someone to talk to is one approach that has been tried in previous research [3]. The advantage of the virtual assistant is that they can accompany them within 24 hours when BPD symptoms appear. In addition, their confidentiality is also better maintained because the virtual assistant does not inform other people about their conversation.

Technically, a voice-based virtual assistant shown consists of a program with a bank of knowledge that can answer based on question patterns, a voice recognizer, and text-to-voice. In previous studies, mobile applications whose gadgets are equipped with voice recognition and text-to-speech features that are connected to a computer server equipped with a knowledge database have been able to answer these needs. The bank of knowledge can be improved according to the needs and development of the case.

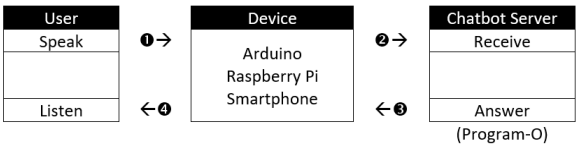

Figure 1. Communication flow in voice-based chatbot

Portable devices like Google Nest and Amazon Alexa should be the solution to answer their needs more interactively. Google Nest and Amazon Alexa are examples of smart speakers that come with Google Assistant. Some activities, such as playing music, turning on the television, asking about the weather, or planning activities, can be done using the user's voice.

However, the device is limited to some functions and cannot connect to the chatbot. To realize a virtual assistant in the form of a portable device, Arduino and Raspberry Pi were explored to be used and connected to a server with a knowledge database. These devices can connect to the server and have the ability to recognize voice using an additional module, a minimum requirement for the voice function on the virtual assistant.

Arduino is an open-source electronic circuit board whose main component is a microcontroller chip with additional components that can be customized according to specific needs. Arduino can be added with a Wi-Fi module to have functionality on an internet connection. The circuit board can be added with a speech recognition module to understand the user's voice. Each addition of modules and functions will increase the power needed by Arduino to work.

The Raspberry Pi is a single-board pocket-sized minicomputer that is equipped with an operating system and can be used to run computer applications. It has Bluetooth, Wi-Fi, and ethernet built-in devices. Like the Arduino board, the Raspberry Pi board can be connected to additional modules to gain access to input/output devices used by desktop computers.

Several aspects, such as the total cost of providing device components, ease of assembling the device, and device functionality of these two devices, will be compared with a smartphone to determine which

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devices are recommended to serve the function as virtual assistants for individuals with BPD. The results can also determine the possibility of the device being developed in other forms, such as smart speakers or other smart devices.

II. CHATBOT KNOWLEDGE MANAGEMENT

Program-O is an open-source web-based application used for knowledge management needed by chatbots in responding to individuals with BPD [3]. The source of the application can be downloaded via the URL https://github.com/Program-O/Program-O. It is used to manage knowledge in Artificial Intelligence Markup Language (AIML) format in terms of adding, changing, deleting, displaying, searching, training, and compiling knowledge formats in AIML.

AIML as a source of knowledge for chatbots must be created using unique question patterns from each other, previous conversation references, or conversation topic groupings. When the patterns of questions are arranged to overlap each other, the resulting responses can be confusing and different from the expectations. For the response to meet expectations, it is necessary to take full advantage of the various tags used in AIML, especially in terms of separating question topics and associating the responses to the context of the previous conversation.

To give different responses to each topic's conversation, AIML has the <topic> tag. Even though the questions are the same, the answers will differ based on the topic set in the previous conversation using the <set> tag. The example of using the <topic> tag in AIML can be seen in Figure 2. When the users talk about movies, the following responses about the marvel and comedy keywords will be different when the users talk about music. The conversation about the pop keyword can be responded to only when the users talk about music.

```
<aiml>
   <category>
      <pattern>* MOVIES</pattern>
      <template>Let's talk about <set name="topic">movies</set></template>
   </category>
   <category>
      <pattern>* MUSIC</pattern>
      <template>Talk about <set name="topic">music</set></template>
   </category>
   <topic name="music">
      <category>
         <pattern>* POP</pattern>
         <template>I do not like pop music</template>
      </category>
      <category>
         <pattern>* MARVEL</pattern>
         <template>I do not have any marvel music soundtrack.</template>
      </category>
      <category>
         <pattern>* COMEDY</pattern>
         <template>Comedy music? I prefer podcast.</template>
      </category>
   </topic>
   <topic name="movies">
      <category>
         <pattern>* MARVEL</pattern>
         <template>Watching Marvel movie stimulates our minds.</template>
      </category>
      <category>
         <pattern>* COMEDY</pattern>
         <template>I like comedy movies too.</template>
      </category>
   </topic>
</aiml>
```

Figure 2. Using tag <topic> to separate topics.

To continue the previous conversation, AIML provides <that> tag to associate the answers with the previous chatbot's responses. Even though the questions are the same, the answers will differ based on the previous chatbot's responses mentioned in <that> tag, as seen in Figure 3.

```
<category>
   <pattern>* HOBBIES</pattern>
   <template>What hobbies do you like?</template>
</category>
<category>
   <pattern>* BASKET</pattern>
   <that>What hobbies do you like</that>
   <template>Do you know Michael Jordan?</template>
</category>
<category>
   <pattern>YES</pattern>
   <that>Do you know Michael Jordan</that>
   <template>Wow I know your age</template>
</category>
<category>
   <pattern>NO</pattern>
   <that>Do you know Michael Jordan</that>
   <template>I understand</template>
</category>
```

Figure 3. Using tag <that> to associate with the previous conversation.

AIML also has the <condition> tag to set the chatbot's response based on the first conversation. Consistent responses will keep users talking in the context of the previous conversation and not having to speak in complete sentences. The example of using the <condition> tag can be seen in Figure 4. When users talk about Bangkok, the following answer is all about Bangkok. The same condition can also be seen when the user talks about the city of Manila and the city of Semarang. The responses will all be related to that city.

```
<category>
    <pattern>* KNOW *</pattern>
    <template>
        <think><set name="quest"><star index="2"/></set></think>
        <condition name="quest">
            <li value="Bangkok">Bangkok is a City of Angels</li>
            <li value="Manila">Manila is a Pearl of Orient</li>
            <li value="Semarang">Semarang is the Venice of Java</li>
            <li>Huum I do not know</li>
        </condition>
    </template>
</category>
<category>
    <pattern>WHERE *</pattern>
    <template>
        <condition name="quest">
            <li value="Bangkok">Bangkok is in Thailand</li>
            <li value="Manila">Manila is in the Philippines</li>
            <li value="Semarang">Semarang is in Indonesia</li>
            <li>I am so sorry</li>
        </condition>
    </template>
</category>
```

Figure 4. Using tag <condition> to follow the conversation.

The chatbot knowledge management should be done to make the individuals with BPD feel comfortable and not feel annoyed by having to repeat questions or because of responses that are not contextually appropriate. The work result of chatbot knowledge management is expected to increase the capability of responding to users. The chatbot responses can be processed in other forms according to the expected target.

Other applications can read the responses from Program-O by setting the output as JSON or XML format. The output will be used to relate the question from the user with the answer stored in the O-Program using any programming language. An example of an application that uses JSON output from Program-O is a LINE-based Virtual Friend named Sovi Lau, which stands for "Sobat Virtual Anti Galau" or "Anti-Stress Virtual Friend" [4]. LINE Messaging API will communicate with the chatbot server by sending the user's message, receiving the JSON-based response,

and displaying responses in sentences humans can understand.

Chatbot responses can be engineered into voice to give users new experiences like talking to friends and might be needed by individuals with BPD.

III. VOICE-BASED CHATBOT DEVELOPMENT

In implementing a voice-based chatbot on all three devices as virtual friends for individuals with BPD as shown in Figure 5, several additional components are needed to perform the following functions: listening to the user's voice, converting voice to text, sending a text to the chatbot server, receiving text responses from the server chatbots, and converting text to voice.

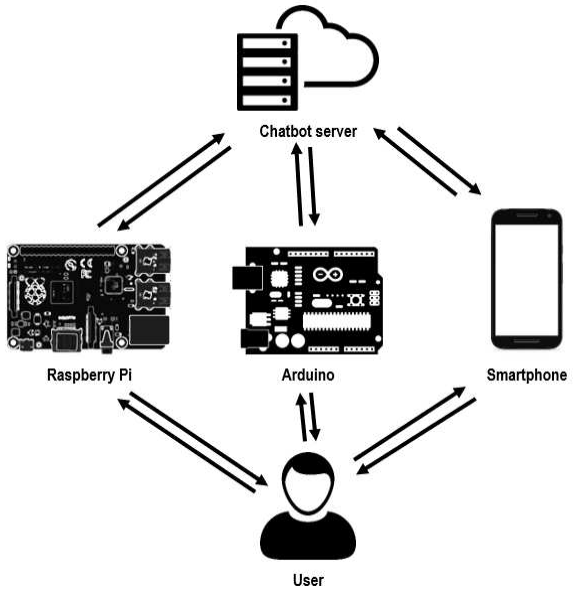

Figure 5. Voice-based chatbot Scenario

A. Arduino

The use of Arduino devices requires additional modules for voice recognition and the internet of things (IoT) [5] as shown in Figure 6. The voice recognition module is used to mediate the user's voice recognition and process it in the microcontroller. While the IoT module is used to send commands from the microcontroller to the chatbot server and receive responses from the chatbot server. The ESPduino-32 board can be used to facilitate the provision of an Arduino that has been equipped with an ESP-32 module for Wi-Fi connection [6]. Voice Recognition Module v3.1 can detect and change voices in certain activities [7]. Approximately all those devices will cost around 30-40 USD.

User		Device		Chatbot Server
Speak	❶→	ESPduino-32 Voice Recognition Module v3.1	❷→	Receive
Listen	←❹	Text-to-Speech API	←❸	Answer
		(Program-O)		

Figure 6. Arduino in voice-based chatbot

B. Raspberry Pi

Raspberry Pi, as a minicomputer [8], has complete functions to process every task, including the Wi-Fi function for transferring the text or any requests to the chatbot server. The board only needs a GPIO expansion board, a ReSpeaker 4-Mic Array module, and a USB microphone as additional devices as shown in Figure 7. The ReSpeaker 4-Mic Array module functions to recognize the user's voice [9], the USB microphone functions as the user's voice input, and the GPIO expansion board functions to mediate the connection between the Raspberry Pi board and ReSpeaker 4-Mic Array module. Approximately all those devices will cost around 200-210 USD.

User		Device		Chatbot Server
Speak	❶→	Raspberry Pi 4 Expansion Board GPIO ReSpeaker 4-Mic Array Mic USB Microphone	❷→	Receive
Listen	←❹	Text-to-Speech API	←❸	Answer
		(Program-O)		

Figure 7. Raspberry Pi in voice-based chatbot

C. Smartphone

Current smartphones can recognize the voice and facilitate text-to-speech. It only requires the mobile application to receive the user's voice, convert the voice to text, send the text to the chatbot server, wait for the text response from the chatbot server, and convert the text to voice, as seen in Figure 8. The application developers can only use MIT App Inventor to provide these functions within the application [10]. This tool has limited skill requirements to operate website-based applications to create Android-based mobile applications [11]. The minimum specifications of a smartphone with the required capabilities will cost around 30-35 USD, depending on the smartphone's brand.

User		Device		Chatbot Server
Speak	❶→	Smartphone's Voice Recognition Text-to-Speech	❷→	Receive
Listen	←❹		←❸	Answer
				(Program-O)

Figure 8. Smartphone in voice-based chatbot

IV. EVALUATION OF DEVICES

Several factors must be considered when deciding which voice-based chatbot device to develop. These factors are cost, difficulty, and functionality. The cost factor is the money spent to develop the device's intended function. The difficulty factor is the effort of providing hardware, technical aspects, and developing the supporting application. The functional factor is the function of understanding the voice, connecting with the chatbot server, and displaying the chatbot response.

A. Device Cost

In assembling the supporting components of a voice-based chatbot using Arduino as the main device, the cost is around 30-40 USD. Assembling a

Raspberry Pi with a voice-based chatbot support devices costs around 200-210 USD. The cheapest smartphone purchases cost around 30-35 USD or more depending on the smartphone brand. The most expensive expense is in assembling the Raspberry Pi. The other two options cost in the same range. The cost comparison of the three devices can be seen in table I.

TABLE I. COST RANK

Device	Cost	Rank
Arduino	30-40 USD	2
Raspberry Pi	200-210 USD	1
Smartphone	30-35 USD	2

B. Device Assembly Difficulty

Raspberry Pi as a minicomputer has the minimum specifications required for office work, but for multimedia purposes, additional components are needed. In terms of providing additional components, the provision of a ReSpeaker 4-mic Array module connected to the Raspberry Pi via the GPIO Expansion Board and voice input using a USB Microphone Mic connected to the Raspberry Pi has the same difficulty as adding components on the Arduino board circuit with ESP32 components to Wi-Fi and Voice Module v3.1 components for voice recognition. However, the use of ESPduino-32 which is a combination of Arduino board and ESP-32 module makes it a little easier and reduces the number of components that need to be provided. The current smartphones have all the functions needed so additional devices to work as planned is not needed. The order of providing the most difficult hardware is Raspberry Pi, Arduino, and smartphone.

After providing the hardware, it is needed to assemble all the components with the main board. Even though Raspberry Pi and Arduino almost have similar effort to assemble, Raspberry Pi has more components to manage than Arduino. smartphones are ready to be used. Users can use all functions needed without any technical intervention. The order of the most difficult technical aspects is Raspberry Pi, Arduino, and smartphone.

A similar situation also occurs when installing programs to make the three devices function as planned. Installing some programs and training the hardware are needed to understand the users' voice. Almost the same as the other two aspects, Raspberry Pi and Arduino almost have the same difficulty, but the Raspberry Pi has more programs to be installed than in the Arduino because Raspberry Pi has an operating system, but Arduino does not. However, each hardware has to be connected to an API to have the needed voice function. The smartphone has operating system features and can work as targeted without any additional APIs. Users only use the existing features through easy procedures. The order of the most difficult application development is Raspberry Pi, Arduino, and smartphone. The comparison of difficulty levels in hardware provision, technical aspects, and application development discussed above can be seen in table II.

TABLE II. LEVEL OF DIFFICULTY

Device	Level of Difficulty		
	Hardware Provision	*Technical Aspects*	*Application Development*
Arduino	2	2	2
Raspberry Pi	1	1	1
Smartphone	3	3	3

C. Device Functionality

Those three tools can achieve the most targeted functions but at different levels of implementation. For example, Arduino can recognize voice only in the form of a word but not in a sentence. Each recognized word will trigger an action on the Arduino. However, Raspberry Pi and Smartphone can recognize the voice in the form of a word or a sentence.

Arduino can perform its functions on the chatbot server connection through the ESP32 module that functions as Wi-Fi. While on the Raspberry Pi, this feature is embedded in the minimum Raspberry Pi package. The same thing is found on smartphones with Wi-Fi by default features. It can be said all three can perform the function of connecting to the chatbot server.

However, compared to the two device's functional experiments above, different results are obtained in getting responses from the chatbot server. Arduino is failed to provide chatbot responses because the voice recognition function through Voice Recognition Module v3.1 is limited to a keyword. The complete words cannot be recognized and an appropriate response cannot be given. Arduino cannot give the expected response because it can only detect one word for each action. The expected answer from responding to complete sentences cannot be achieved. Both Raspberry and smartphones can recognize long sentences and can provide responses from appropriate chatbots. The ReSpeaker 4-Mic Array module connected to the Raspberry Pi enables speech recognition and functions within Amazon Alexa and Google Home. While the voice features that have been embedded in the smartphone make it a facility from the start. The comparison of functionality in voice recognition, connection to chatbot server, and chatbot responses for the three devices discussed above can be seen in table III.

TABLE III. DEVICE'S FUNCTIONALITY

Device	Functionality		
	Voice recognition	*Connection to chatbot server*	*Chatbot responses*
Arduino	V	V	X
Raspberry Pi	V	V	V
Smartphone	V	V	V

V. CONCLUSIONS

The devices used to integrate voice recognition features with AIML-based chatbots that function as needed are smartphones and Raspberry Pi. But in terms of cost, a smartphone with low specifications for 30-35 USD can be used for these needs. While the cost of Raspberry Pi reaches 200-210 USD. In terms of difficulty level, Raspberry Pi has a greater level of difficulty than a smartphone.

The integration of voice recognition features with an AIML-based chatbot can be done by utilizing the speech recognition and text-to-speech features in smartphones and available features in making applications using MIT App Inventor. Speech recognition translates the user's voice into text and sends it to the chatbot server. Then, the chatbot server will receive the sent sentence and answer based on its word pattern. By a smartphone, the answer will be converted into voice through the text-to-speech feature and played for the user.

Overall, based on the benchmarking of the three devices, the use of smartphones is recommended in presenting voice recognition features in chatbots as it is faster, cheaper, and easier. Making a smartphone application using MIT App Inventor can already activate the voice recognition and text-to-speech functions needed for a voice-based chatbot.

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