

WAEI: An Intelligent Chatbot for Helping Fighting the Pandemic Infodemic

Yahya Almortadha
Faculty of Computers and Information
Technology
University of Tabuk
Tabuk, Saudi Arabia
y.murtadha@ut.edu.sa

Mukhtar Ghaleb
Faculty of Computing and Information
Technology
University of Bisha
Bisha, Saudia Arabia
mghaleb@ub.edu.sa

Mohamed Ahmed Alomari
(IEEE Senior Member
Faculty of Technology & Electronic
and Computer Engineering (FTKEK)
Universiti Teknikal Malaysia Melaka
Melaka, Malaysia
alomari@utem.edu.my

Ibrahim Ahmed Al-Balatah
Faculty of Science and Engineering
Al-Hikma University
Sana'a, Yemen
albalatah2020@gmail.com

Abstract— The World Health Organization (WHO) began warning of a possible upcoming epidemic called monkeypox, while humanity is still suffering from the consequences of the latest epidemic. In addition to various health issues caused by the Covid-19 pandemic, an “infodemic” accompanied the virus that led to the spread of many fake news about the virus and possible medication treatments. This fake news led to the emergence of huge mass panic causing stress and anxiety and might lead to death. This paper proposes an intelligent Chatbot called WAEI (Arabic term means awareness in English) to increase the awareness of pandemic risks, methods of prevention, and precautionary measures. WAEI fight the infodemic by producing responses based on its knowledgebase that was formed from credible sources, namely the WHO. The Chatbot uses Natural Language Understanding (NLU) to infer its responses. 308 volunteers evaluated the proposed chatbot. The volunteers’ responses were statistically analyzed to measure whether the Chatbot is resourceful, coherent, and achieves user satisfaction. Precision, recall and F1 metrics shows improvement in accuracy, which reach 83% accuracy in responding to users’ inquiry. WAEI is of great value and has been proposed at the right time for the health sectors as it gives a good experience in using technology and smart systems to quickly handle infodemic effectively by providing necessary awareness for any potential foreseen diseases.

Keywords—Chatbot, Covid-19 Pandemic, Infodemic, Conversational agent.

I. INTRODUCTION

Recently, many countries have begun taking health precautions and monitoring borders to limit the potential spread of monkeypox. They have learned from the experience of the COVID-19 pandemic that it has encouraged governments globally to go digital. In fact, using smart technologies is advancing citizens daily tasks faster than ever noticed in history and has transformed societies to the digital era. On the other hand, artificial intelligent (AI) based services are becoming more reachable to facilitate people’s life and to increase their well-being. AI can also understand data and learning from data on a scale that no human can achieve. This ability can bring significant benefits to the individual and society. Despite of the success around the learning ability of AI, it aims to enhance human productivities and contributions significantly. For example, In the education sector, virtual and distance learning environments have enabled access to study programs for millions of students who were vulnerable during

the Covid-19 pandemic. In the health sector, the groundbreaking artificial intelligence AI-enabled solutions are assisting Covid-19 researchers in disease diagnosis and medicine inspection, resulting in faster vaccine discovery [1].

During the Covid-19 pandemic, individuals experience stress, anxiety, and fear, which worsen mental health disorders and causes depression [2]. The reason for this could be the availability of variant information, rumors, and misinformation that makes you feel out of control and confused about what to do. There are many myths and misinformation about the new coronavirus (commonly known as COVID-19) on the internet. That includes how COVID- 19 spreads, how one can stay safe, and what to do if you are concerned about the possibility of contacting the virus. Therefore, it is important to be careful when seeking information and advice. Consequently, WHO and many world governments have established specialized websites integrated by Chatbot to provide reliable information about Corona disease to reduce the effects resulting from the spread of false information about this virus. The Chatbot responds correctly and quickly to user inquiries based on a set of steps, as follows:

- 1) Data reception and input: The robot starts fetching data from the user right when they start talking.
- 2) Data analysis: in turn, the system begins by analyzing the user inquiry, aiming at finding the best model answer that satisfies users thirst for answers. This step is vital since the more accurate the analysis, the more precise and useful the answer. Provide the answer: The Chatbot response is either a pre-defined text for repeated tasks or if more intelligent is a result of accurate understanding of user intents and mapping of the entities and reactions from the knowledgebase. Fig. 1 illustrates how a Chatbot works.

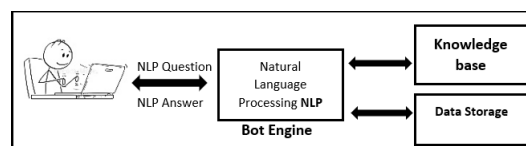


Fig. 1. How a Chatbot works.

The remainder of this paper is as follows: section II discusses the literature review on the chatbot. Section III discuss the methodology of developing WAEI chatbot and deploy it to the users. Section IV discuss the experimental results and how we evaluate the accuracy of the chatbot..

II. LITERATURE REVIEW

Conversational agent or Chatbot, which is a machine agent that serve as natural language user interfaces for data and service providing, is gaining popularity. It can be defined as a specialized conversational program based on artificial intelligence in interacting with the human user through a language that the latter understands through various channels such as websites and smartphone applications. It is an important tool that implements the system of presenting useful information as an exemplary answer to the questions asked.

People communicate with one another through talk, which is the most common mode of communication. This interaction was inspired by AI, which led to the development of intelligent conversation agents to improve human-to-computer communication. Several studies attempted to develop intelligent conversation systems to assist humans in various activities in diverse sectors. The highly evolved intelligent conversation agents lead researchers like [3] to believe that the conversational agent has human-like characteristics, and in certain cases, they even believe it has a gender. Chatbots have been adopted in various sectors, including education, health, and business. The authors in [4] provide an in-depth examination of unleashing the potential of Chatbots in Education. Labeeb, an intelligent conversational agent developed to answer students' inquiries on specific courses, was introduced in [5].

From another perspective, [6] tried to develop a chatbot for MATLAB practical dataset in a normal fashion. Students can submit text-based inquiries to the chatbot, which is subsequently processed them using NLP. At the final stage, the Chatbot can provide precise replies to the student queries. As a result, this type of chatbot is beneficial to both students and teachers. Bengali Chatbot for education purposes was proposed and reported in [7]. It is a full data-driven retrieval-based closed-domain Chatbot that can effortlessly converse with people in Bengali. Another Chatbot that focus on understanding the Saudi dialect was proposed by [8].

The authors in [9] proposed an entertainment Chatbot for supporting users' cultural heritage path. An analysis of proposed chatbots developed to measure users' satisfaction is introduced in [10]. In health sector, there are many researchers who benefits from chatbot technology in order to combat COVID-19 pandemic [11]–[16]. However, the proposed chatbot was developed to serve the health sector in Saudi Arabia to increase the awareness of citizens and residents about COVID-19 pandemic. However, it is clear that the knowledge of body needs variant Chatbots for different goals including pandemic infodemic.

III. METHODOLOGY

The purpose of the study is to show the benefit of using smart technologies in providing appropriate awareness to the public to avoid panic. An investigative trial of a previous pandemic (Covid-19) was used as a sample. We used Dialogflow [17] platform to develop a Covid-19 chatbot as illustrated by Fig. 2. Dialogflow uses two algorithms to match user intents with the best answer: rule-based grammar

matching and ML matching. Dialogflow normally tries both algorithms and picks the optimum response [18]. The information used to form the knowledge of the chatbot was extracted from World Health Organization (WHO) website. We preprocessed this information transforming it into groups of entities and intents to help the chatbot engine identifies the inquiry by the user and then respond correctly. Jaccard similarity in equation 1 is a method for determining similarity. The similarity of an inquiry (Inq) and a generated list of related intents and entities is calculated using Jaccard similarity (Res). It is calculated as follows:

$$J(Inq, Res) = \frac{|Inq \cap Res|}{|Inq \cup Res|} = \frac{|Inq \cap Res|}{|Inq| + |Res| - |Inq \cap Res|} \quad (1)$$

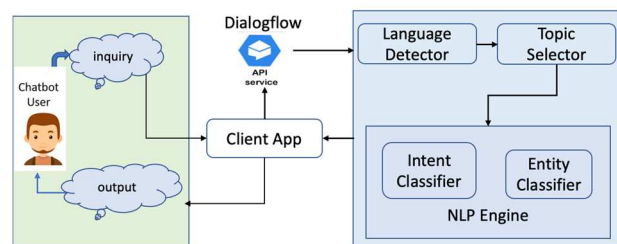


Fig. 2. WAEI Chatbot

Fig. 3 and Fig. 4 shows samples of chatbot responses to users' inquiries illustrating the inquiries and the responses in Arabic language and their translation in English for to give a clear idea of the chatbot accuracy.



Fig. 3. The System response to the question "translation: How to sterilize vegetables and fruits?".

Fig. 2. Is Corona transmitted from mother to infant?

A link of the developed chatbot was send publicly for the purpose of testing. For the period of two months of January and February, 308 users respond to this link by using the chatbot, then recorded their experience by answering a questionnaire. The questionnaire as in Table I was designed to reflect if the chatbot would achieve three usefulness criterions: resourceful, coherent and satisfaction.

TABLE I. VARIABLE FREQUENCIES AND PERCENTAGES

No.	Question	Possible Answers				
1	Gender	Male		Female		
2	Marital Status	Single	Married	Divorced	Widow	
3	Employment Status	Student	Employee	Unemployed		
4	Education Level	Elementary	Secondary school	High school	Graduate	Postgraduate
5	Age	<=15	16-30	31-45	46-59	>=60
6	Are you a diabetes?	Yes	No			
7	Have you been previously, diagnosed with high blood pressure?	Yes	No			
8	Have you had a lung infection or any chest disease?	Yes	No			
9	Do you suffer from other chronic diseases?	Yes	No			
10	Do you suffer from any psychological pressure?	Yes	No			
11	Do you smoke?	Yes	No			
12	Have you ever used the smart chat system before?	Yes	No			
13	Have you ever used another smart chat system to inquire about Coron-avirus?	Yes	No			
14	When you use the Corona smart chat program, are you satisfied with the language and expressions used when answering your inquiries?	Very Satisfied	Satisfied	I don't Know	Unsatisfied	Absolutely not Satisfied
15	What is your evaluation of the speed of response to the smart chat system?	Very Satisfied	Satisfied	I don't Know	Unsatisfied	Absolutely not Satisfied
16	How would you rate the system's response to your inquiries about Corona?	Very Satisfied	Satisfied	I don't Know	Unsatisfied	Absolutely not Satisfied
17	What is your evaluation of the smart chat program in general?	Very Satisfied	Satisfied	I don't Know	Unsatisfied	Absolutely not Satisfied
18	What is your evaluation of your private information about Corona virus?	Very High	High	I don't Know	Low	Very Low
19	What is your evaluation of the effectiveness of the available means to raise awareness about the Coronavirus (text messages, health web- sites ... etc.)?	Very High	High	I don't Know	Low	Very Low
20	From your point of view, what is the impact of technology in promoting health awareness in the community?	Very High	High	I don't Know	Low	Very Low
21	How much do you support the idea of using the chatbot as a new aware- ness system?	Very High	High	I don't Know	Low	Very Low
22	From your point of view, how much does the chatbot contribute in increasing your information about Corona?	Very High	High	I don't Know	Low	Very Low
23	What is the level of your satisfaction with the ease of dealing with the smart chat program?	Very Satisfied	Satisfied	I don't Know	Unsatisfied	Absolutely not Satisfied
24	Are you satisfied with the quality of the information you got from the smart chat program?	Very Satisfied	Satisfied	I don't Know	Unsatisfied	Absolutely not Satisfied
25	What is your level of satisfaction with the use of the smart chat pro- gram in general?	Very Satisfied	Satisfied	I don't Know	Unsatisfied	Absolutely not Satisfied
26	How satisfied are you with recommending others to use the new Corona smart conversation system?	Very Satisfied	Satisfied	I don't Know	Unsatisfied	Absolutely not Satisfied

IV. SYSTEM EVALUATION

The goal of the evaluation is to assess the ability of the chatbot to correctly understand the users' inquiries and then accurately respond to them especially that the chatbot is of great importance in the time of Coronavirus pandemic. Dialogflow Console offers an analytics option that displays the chatbot request and response data statistics. Such an option is of great interest to the chatbot developers as it gives an idea of how the chatbot is actively used by the users, which gives room for improvement. These analytics is based on time slots, so we choose to explore the chatbot analytics for January and February, which are the two months for testing the chatbot, as illustrated by Fig. 5 and Fig. 6 consequently. For the session analytics, the x-axis displays several working sessions during that hour of the day. It can be seen from the graphs that in February, there was a moment when 40 sessions were running simultaneously. The interaction analytics reveal intent call counts via direct API calls and indirect calls via integrations.

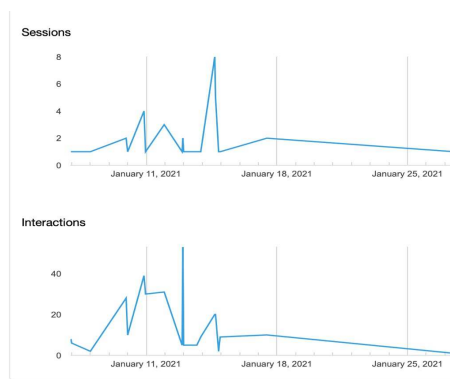


Fig. 3. Dialogflow transactions analytics - January

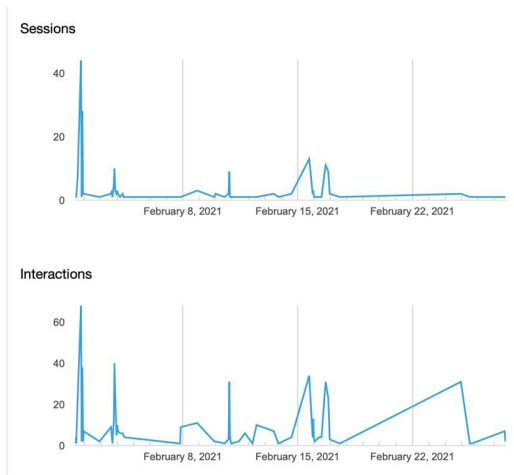


Fig. 4. Dialogflow transactions analytics - February.

Questionnaire questions were structured into three themes with reliability of 0.857 as measured by Cronbach's Alpha [19]:

- 1) Investigating if the users have previously used any chatbot in general and Covid-19 particularly,
- 2) Satisfaction of using the Covid-19 chatbot and recommend it to others,

- 3) If users' awareness has been increased by using the chatbot.

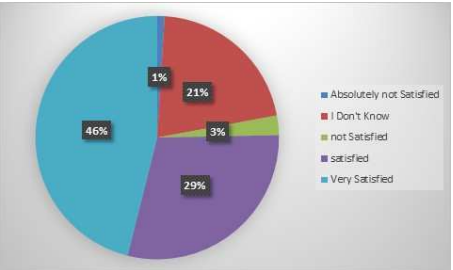
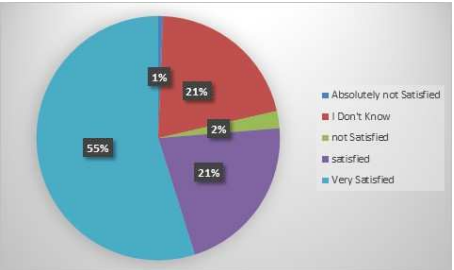
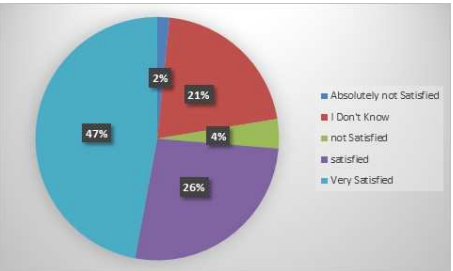
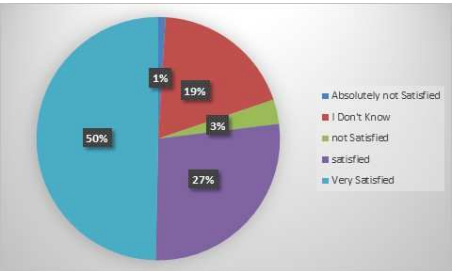
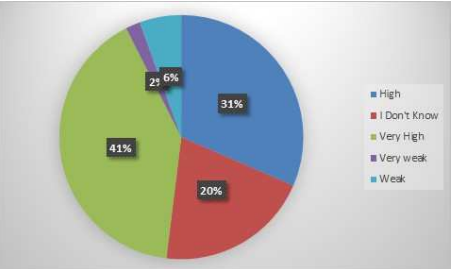
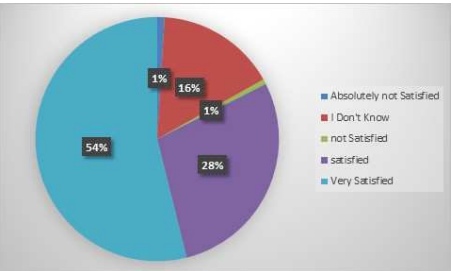
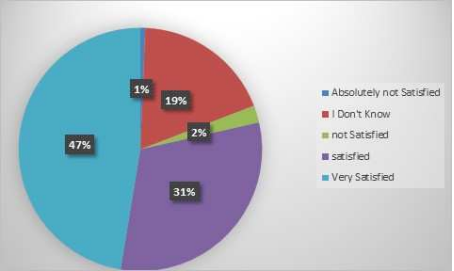
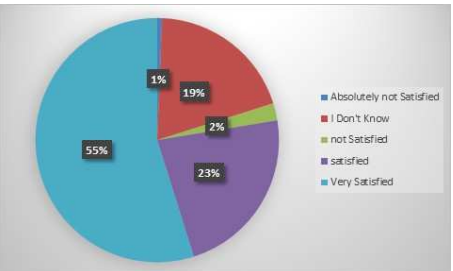
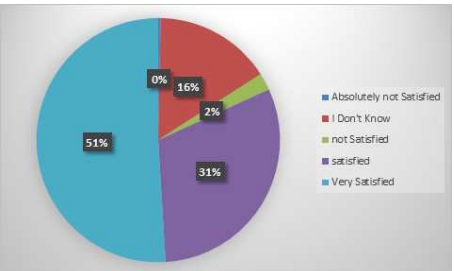
TABLE II. DESCRIPTIVE ANALYSIS RESULTS

Variable	Frequency	Percent%
Gender		
Male	149	48.4
Female	159	51.6
Total	308	100
Occupation		
Student	160	51.9
Employee	136	44.2
Unemployed	12	3.9
Total	308	100
Marital Status		
Single	168	54.5
Married	138	44.8
Divorced	2	0.6
Total	308	100
Education Level		
Elementary	3	1
Secondary	4	1.3
High School	28	9.1
Graduate	149	48.4
Postgraduate	124	40.3
Total	308	100
Age		
Less than 15 years	7	2.3
15-30 years	175	56.8
31-45 years	105	34.1
46-59 years	20	6.5
60 years and above	1	0.3
Total	308	100

To measure these hypotheses accurately with real users, we sent and circulated a link of the chatbot publicly via WhatsApp with an open invitation to use, evaluate and send to others. To examine the effectiveness of using the chatbot, the users' awareness, and satisfaction, a questionnaire was also distributed. We used Google forms to construct the questionnaire. The questionnaire was mainly divided into three main parts. The first part aims to measure the knowledge of those who responded to the questionnaire using a chatbot system. The second part aims to measure the users' awareness created by using the chatbot system. Finally, the third part aims to measure the extent of the users' satisfaction in terms of chatbot functionality, effectiveness, response precision, and speed of response. Using Morgan's table [20] for calculating the sample size, 385 users will be suitable for representing the experience of Saudi Arabia population. 308 (response rate 80%) responses were received. Table II presents the descriptive statistic of users. The results show that the minority of respondents were male (48.4%), unemployed (3%), divorced (6%) and less than 15 (7%) and above 46 years old (21%).

The matrix in Table III illustrates the statistical distribution of real users' responses for evaluation purpose. It can be seen that the proposed chatbot has been effectively answering the users' inquiries with 77% highly satisfied with using the chatbot. 72% shows that the chatbot has increased their awareness on Covid-19. 51% were very satisfied and additionally more 31% were satisfied (82%) of using the chatbot. Finally, 78% would recommend using this chatbot to others.

TABLE III. STATISTICAL DISTRIBUTION OF REAL USERS' RESPONSES

Standard	Question and Real Users Responses distribution	
Resourceful	When you use the Corona smart chat program, are you satisfied with the language and expressions used when answering your inquiries?	What is your evaluation of the speed of response to the smart chat system?
		
	How would you rate the system's response to your inquiries about Corona?	What is your evaluation of the smart chat program in general?
		
Coherence	From your point of view, how much does the chatbot contribute in increasing your information about Corona?	
		
Satisfaction	What is the level of your satisfaction with the ease of dealing with the smart chat program?	Are you satisfied with the quality of the information you got from the smart chat program?
		
	How satisfied are you with recommending others to use the new Corona smart conversation system?	What is your level of satisfaction with the use of the smart chat program?
		

We used a preprocessed COVID-QA dataset on Kaggle includes 800+ pairs questions and interrelated answer <https://www.kaggle.com/xhlulu/covidqa>. The dataset was divided into training (70%) and testing (30%) sets. To measure the performance, we used the Accuracy, Precision, Recall and F1.

$$Accuracy = \frac{TP+TN}{TP+TN+FP+FN} \quad (2)$$

$$Precision = \frac{TP}{TP+FP} \quad (3)$$

$$Recall = \frac{TP}{TP+FN} \quad (4)$$

$$F1 = 2 * \frac{Precision*Recall}{Precision+Recall} \quad (5)$$

The experiment was trained on set QA={ (q1 , a1), (q2, a2), ..., (qn , an) } of pairs (question+ answer). Since this dataset is in the text format, K- Nearest Neighbor (KNN) algorithm used to examine the framework in RapidMiner tool. We slightly modified the number of questions to test the effectiveness of the proposed architecture, as shown in Table IV. The table shows that accuracy improves as the number of questions increases. Precision measures the capability of a classification model to recognize the questions that belong to a specific topic. Recall measures the capability of the classification model to recognize all the questions related to a specific topic of Covid-19. The precision and recall metrics used to calculate the F1 measure that harmonize these values and indicates the average of precision and recall.

TABLE I. EXPERIMENTAL RESULTS OF PRECISION, RECALL AND F1

Number of Questions	accuracy	precision	recall	classification error	F1
150	83.1	82.7	83.1	18.8	82.89
100	79.4	78.2	79.4	20.5	78.79
50	72.3	76.1	77.6	21.8	76.84

V. CONCLUSION AND FUTURE WORKS

This study originated in light of the current fear of an upcoming epidemic known as monkeypox [21] that may confront humanity and bring back painful memories of Covid-19. The impact of Covid-19 pandemic has encouraged an urgent need to benefit from the technology and use smart chatbots with a trusted source knowledge base for several reasons. First, the chatbot provides awareness information to help fighting the pandemic indirectly by following the precautionary measurements. Second, it helps health workers to spend their time healing and curing patients instead of sitting in front of the disks to answer questions. Third, the chatbot fights the infodemic accompanying the pandemic due to the viral spread of fake news. The proposed chatbot uses Natural Language Understanding NLU to comprehend the users' inquiries and then infer its responses. The proposed chatbot was evaluated by 308 online volunteering users who responded to a public invitation - to try and evaluate - messages sent on social media. WAEI shows an accuracy of 83% in responding to user's inquiries. The evaluation results and statistical analysis report the chatbot's resourcefulness, coherence, and satisfaction. Future work shall consider adding additional features such as multilingual understanding.

REFERENCES

- [1] G. Arora, J. Joshi, R. S. Mandal, N. Shrivastava, R. Virmani, and T. Sethi, "Artificial intelligence in surveillance, diagnosis, drug discovery and vaccine development against covid-19," *Pathogens*. 2021. doi: 10.3390/pathogens10081048.
- [2] V. Gianfredi, S. Provenzano, and O. E. Santangelo, "What can internet users' behaviours reveal about the mental health impacts of the COVID-19 pandemic? A systematic review," *Public Health*. 2021. doi: 10.1016/j.puhe.2021.06.024.
- [3] S. Brahnam and A. De Angeli, "Gender affordances of conversational agents," *Interact. Comput.*, vol. 24, no. 3, pp. 139–153, 2012, doi: 10.1016/j.intcom.2012.05.001.
- [4] R. Winkler and M. Soellner, "Unleashing the Potential of Chatbots in Education: A State-Of-The-Art Analysis," *Acad. Manag. Proc.*, 2018, doi: 10.5465/ambpp.2018.15903abstract.
- [5] Y. ALMURTADHA, "LABEEB: Intelligent Conversational Agent Approach to Enhance Course Teaching and Allied Learning Outcomes attainment," *J. Appl. Comput. Sci. Math.*, vol. 13, no. 1, pp. 9–12, 2019, doi: 10.4316/jacsm.201901001.
- [6] E. Kasthuri and S. Balaji, "A chatbot for changing lifestyle in education," in *Proceedings of the 3rd International Conference on Intelligent Communication Technologies and Virtual Mobile Networks, ICICV 2021*, 2021. doi: 10.1109/ICICV50876.2021.9388633.
- [7] M. Kowsher, F. S. Tithi, M. Ashraf Alam, M. N. Huda, M. Md Moheuddin, and M. G. Rosul, "Doly: Bengali Chatbot for Bengali Education," in *1st International Conference on Advances in Science, Engineering and Robotics Technology 2019, ICASERT 2019*, 2019. doi: 10.1109/ICASERT.2019.8934592.
- [8] D. Al-Ghadhban and N. Al-Twairish, "Nabiha: An Arabic dialect chatbot," *Int. J. Adv. Comput. Sci. Appl.*, 2020, doi: 10.14569/ijacsa.2020.0110357.
- [9] G. Sperli, "A deep learning based chatbot for cultural heritage," in *Proceedings of the ACM Symposium on Applied Computing*, 2020. doi: 10.1145/3341105.3374129.
- [10] F. Aulia, C. Adviorika U. Yuniarty, M. Fahlevi, H. Prabowo, and B. G. Muchardie, "Analysis of chatbot program features towards customer satisfaction in the era of digitalization," in *Proceedings of 2021 International Conference on Information Management and Technology, ICIMTech 2021*, 2021. doi: 10.1109/ICIMTech53080.2021.9535034.
- [11] M. Ghaleb et al., "Mining the chatbot brain to improve COVID-19 bot response accuracy," *Computers, Materials and Continua*. 2022. doi: 10.32604/cmc.2022.020358.
- [12] J. J. Sophia and T. P. Jacob, "EDUBOT-A Chatbot for Education in Covid-19 Pandemic and VQAbot Comparison," in *Proceedings of the 2nd International Conference on Electronics and Sustainable Communication Systems, ICESC 2021*, 2021. doi: 10.1109/ICESC51422.2021.9532611.
- [13] K. Gaglo, B. M. Degboe, G. M. Kossingou, and S. Ouya, "Proposal of conversational chatbots for educational remediation in the context of covid-19," in *International Conference on Advanced Communication Technology, ICACT*, 2021. doi: 10.23919/ICACT51234.2021.9370946.
- [14] E. Amer, A. Hazem, O. Farouk, A. Louca, Y. Mohamed, and M. Ashraf, "A Proposed Chatbot Framework for COVID-19," in *2021 International Mobile, Intelligent, and Ubiquitous Computing Conference, MIUCC 2021*, 2021. doi: 10.1109/MIUCC52538.2021.9447652.
- [15] M. Naufaldi, S. Jovita, C. M. Frans, M. L. I. Hanafi, and N. N. Qomariyah, "COBY: COVID-19 Telegram Chatbot by Employing Machine Learning Algorithms," in *8th International Conference on ICT for Smart Society: Digital Twin for Smart Society, ICISS 2021 - Proceeding*, 2021. doi: 10.1109/ICISS53185.2021.9533198.
- [16] W. El Hefny, A. El Bolock, C. Herbert, and S. Abdennadher, "Chase Away the Virus: A Character-Based Chatbot for COVID-19," in *SeGAH 2021 - 2021 IEEE 9th International Conference on Serious Games and Applications for Health*, 2021. doi: 10.1109/SEGAH52098.2021.9551895.
- [17] L. Boonstra, "Creating a Multilingual Chatbot," in *The Definitive Guide to Conversational AI with Dialogflow and Google Cloud*, 2021. doi: 10.1007/978-1-4842-7014-1_8.

- [18] D. E.E., S. C.J., D. O.S., and D. O.E., "Covid-19 I-SABI Chat-bot application using the natural language processing with Dialog-flow," *Innov. J. Sci.* (ISSN 2714-3309), 2021.
- [19] H. Park, "Reliability using cronbach alpha in sample survey," *The Korean Journal of Applied Statistics*, vol. 34, no. 1, pp. 1–8, 2021.
- [20] A. M. Adam, "Sample Size Determination in Survey Research," *J. Sci. Res. Reports*, 2020, doi: 10.9734/jsrr/2020/v26i530263.
- [21] [21] Y. M. Dou, H. Yuan, and H. W. Tian, "Monkeypox virus: past and present," *World Journal of Pediatrics*. 2023. doi: 10.1007/s12519-022-00618-1.