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iJIM International Journal of Interactive Mobile Technologies

iJIM | eISSN: 1865-7923 | Vol. 17 No. 19 (2023) | OPEN ACCESS

https://doi.org/10.3991/ijim.v17i19.36263

PAPER

Artificial Intelligence-Based Chatbot to Support Public Health Services in Indonesia

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ABSTRACT

The aim of this study is to build an artificial intelligence chatbot application to support public health services. The chatbot acts as an information service that can replace the role of humans. The analysis of functional needs was obtained from information submitted by one of the heads of public health centers in Indonesia. This study uses the Scrum method with pregame stages to produce a plan consisting of functional and non-functional requirements analysis and conceptual design of the chatbot, which will be developed using Unified Modeling Language (UML) diagrams. The process of finding answers uses the matching graph master technique, which is a backtrack matching that utilizes a depth-first search strategy. There are 6 topics of chatbot services, including service schedules, health information, registration, diseases, drugs, and early care services for chatbot users. Tests conducted on these 6 topics showed an average correct answer ratio of 93.1% out of a total of 251 questions. The result of the usability measurement on the chatbot application that has been built obtained a system usability scale value of 80.1, indicating that the developed chatbots are acceptable for use.

KEYWORDS

chatbots, artificial intelligence, AIML, graph master, chatbot to support public health services

1 INTRODUCTION

The Industry 4.0 revolution opens up opportunities for industries to implement artificial intelligence, process big data, and carry out software development [1]. This is not an exception in the field of healthcare [2], where it is crucial to focus on open access to information for the general public [3].

Indonesia faces potential risks in the field of health due to its dense population [4]. Based on the data available in Figure 1, the percentage of people who have experienced health complaints in the last month averaged 23%, indicating a relatively high rate of health complaints in Indonesia.

Setiawan, R., Iskandar, R., Madjid, N., Kusumawardani, R. (2023). Artificial Intelligence-Based Chatbot to Support Public Health Services in Indonesia. *International Journal of Interactive Mobile Technologies (iJIM)*, 17(19), pp. 36–47. https://doi.org/10.3991/ijim.v17i19.36263

Article submitted 2022-10-20. Revision uploaded 2023-07-06. Final acceptance 2023-08-05.

Challenges in healthcare stem from various factors, including the shortage of healthcare personnel and the spread of various diseases, making it difficult for many countries to address health problems [5]. The inability of health workers in the field and insufficient health data documentation systems are also significant obstacles in the provision of services [6]. Professionalism is a fundamental aspect of healthcare, and the application of technology is a crucial part of providing professional services [7].

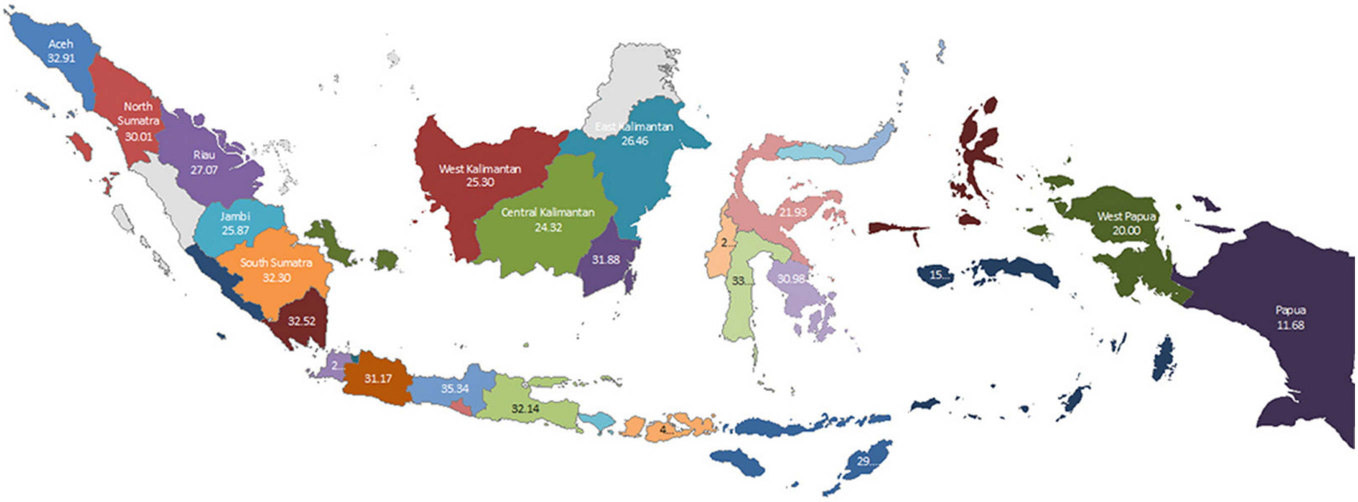

Fig. 1. The percentage of people who have experienced health complaints over the last month

Healthcare is currently at the forefront of the mobile revolution [8], and software in the healthcare field is growing rapidly with the increasing use of mobile devices, such as smartphones, in society [9], [10], [11]. This integration of technology has significantly improved human life activities [12], [13], making technology an inseparable part of daily life [14]. With the growing use of the Internet and the development of health-related technologies, such as telemedicine, telehealth, and telenursing, telemedicine has emerged as one of the alternative ways of providing health and nursing services.

Telemedicine or telehealth-based healthcare systems involving humans as operators still have limitations, including service hours and the officials' understanding in answering various questions, as well as problems with communication abilities. Chatbots serve as automatic communication machines to answer user questions [15]. They simulate human conversational language through computer programs [16] using a natural language approach [17]. The presence of chatbots can help organizations meet various needs [4], [18], and provide cost-effective and timely information services [3]. The ease and flexibility offered by chatbots make them highly valuable for users [19].

The application of chatbots as a medium or tool to provide information has been extensively researched. In 2020, [20] conducted research on online health medical suggestions designed with a modular system to adapt to various medical scenarios. In another study, [21] used cosine similarity calculations to classify questions and employed TF-IDF to determine the relevance of a question to the answers available in the dataset. Moreover, [22] utilized text and voice messages as input, which were then processed using machine learning to predict the type of disease experienced by patients and monitor health conditions in Covid-19 cases.

Open access to health information is a significant challenge. This research aims to develop chatbots that support the public in the process of searching for health information, thereby making access to health services easily accessible and increasing public satisfaction with health information services.

2 METHODS

In this study, the method used is Agile, which is one of the software development methodologies [23]. There are various frameworks within Agile, one of which is Scrum. Scrum was chosen because of its advantages in running design sprint iterations in a short period of time. It is designed to be fast, lightweight, and flexible [24]. The process of analyzing user requirements in Scrum is carried out at the beginning, taking input from the end user to initiate the Scrum process. Scrum is the most suitable method for developing chatbots because of its constant meetings that actively involve the team in the project [25]. The Scrum process involves three stages: pregame, game, and postgame.

1. In the pregame stage, there are two sub-stages: planning and architectural design. Planning involves discussions with the head of the public health center to determine the features that will be developed in the application. The architectural design sub-stage is where the software architecture is designed based on the features to be developed.
2. During the Game Stage, the activities carried out are analysis and design. The analysis is based on the planning done in the early stage of the pregame, resulting in the conceptual design of the system to be developed.
3. Postgame is the stage of demo and product delivery. Before the product is delivered, product testing is conducted to ensure it has been developed according to the user's needs.

The Scrum method is chosen because the daily meetings conducted at each sprint period can identify potential problems that may arise during the system development process and can be addressed by the entire team.

3 RESULTS

3.1 Pregame stage

At the pregame stage, an agreement was reached with the head of the community health center, which was discussed in terms of the proposed system flow, user needs, and functionality requirements.

A) *Planning*
   1) *Functional Needs*
      1. The application should be capable of managing a list of questions about public health services, including features to view, add, and delete questions.
      2. The application should be able to provide answers to every question asked by the user.

3. The application should be able to save every question asked by the public into the database.
4. The application should display statistics of frequently asked questions.

2) *Non-Functional Needs*
   1. The application should be available and operational 24/7 without any interruptions, with the ability to be updated at any time.
   2. The application should have a high level of security, ensuring that every user can only access and modify their own data, preventing unauthorized access to others' accounts.

B) *Architectural Design*

Designing software systems is a lengthy process that can be carried out in various ways [26]. Unified Modeling Language (UML) diagrams are considered the main component in the software requirements engineering process and have become a standard reference in many companies [27]. The system's use case diagrams are drawn and explained in the following points. Use case diagrams describe the functional requirements of the system being developed and the relationship between the system and the external environment [26]. There are two actors involved in the system: the community, which is the actor that interacts most frequently with the chatbot to ask various health service-related questions, and the chatbot, which automatically answers each question based on the patterns stored in the database, previously inputted by the administrator. The use case diagram of the public health service chatbot is illustrated in Figure 2.

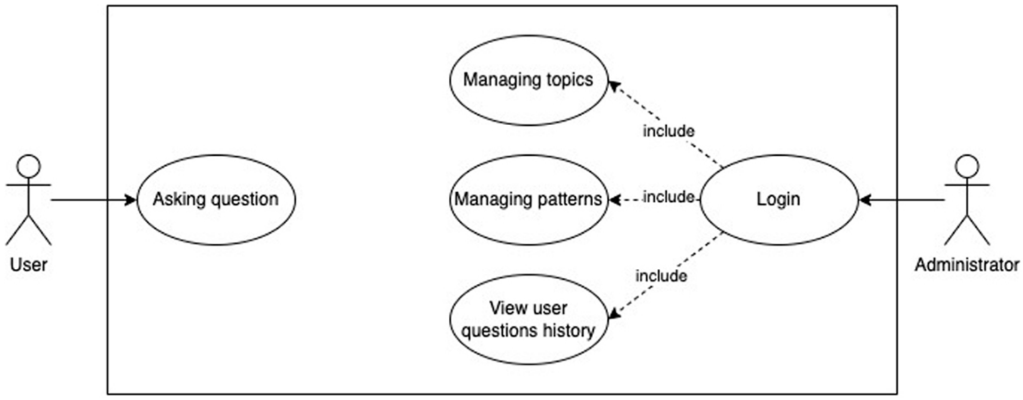

Fig. 2. Use case diagram of the public health service chatbot

3.2 Game stage

A) *Analysis*

The necessary datasets for chatbots are collected from the data available on the service procedures in the public health center. Additionally, data is obtained through interviews with health nurses. This data includes information on the types of health services, service times, health information, and the most frequently asked questions by the public, along with the corresponding answers given to those questions.

The dataset is stored in a database and will be called by the application in the form of a JSON file. An example of JSON files for healthcare topics is provided.

```
<category>
<pattern> * Dentist </pattern>
<template> Dentist services open on Mondays at 9 am
</category>

<category>
<pattern> * Dentist * </pattern>
<template> Dentist services open on Mondays at 9 am
</category>

<category>
<pattern> Dentist * </pattern>
<template> Dentist services open on Mondays at 9 am
</category>
```

The pattern is a question given by the chatbot user. The asterisk (*) sign in the pattern represents any word that is at the beginning or end of the pattern as show in Table 1.

Table 1. Sample question

* (Prefix Word)	Pattern	* (Last Word)
Tell me about	Dentist	
Is there a	Dentist	today?
	Dentist	there?

The answers to each question are grouped according to the topic of the question, and the number of patterns for each topic is shown in Table 2.

Table 2. Topics and patterns

Topic	Patterns	Description
Salutation	8	Initial conversation greeting from the system for chatbot users
Service Schedule	23	Questions about health services
Health Information	34	Questions regarding health information
Registration	26	Questions regarding registrations
Disease	28	Questions about disease
Drug	29	Questions about drugs

B) *Conceptual Design*

1) *Pattern Matching Method*

Graph master is a method used for storing stimulus-response categories from Artificial Intelligence Markup Language (AIML). To achieve efficiency in pattern matching and memory usage, AIML utilizes the graph master method [28], where all category tags <category> in AIML are stored in the form of a tree starting from the root node "*" to a certain path from a pattern.

Graph master is structured as a tree. When a client interacts with the bot (agent) and enters text as a stimulus, the graph master searches for matching categories and associates them with the <pattern> function based on the context of the sentence, then produces an output <template> in response.

Graph master matching is a backtrack matching process that employs a depth-first search strategy. Depth-first search is a type of blind search, wherein the search explores nodes in depth, moving from the initial node to the most recent or until a match is found. In other words, it prioritizes visiting child nodes first.

The stages of the graph master Pattern Matching Algorithm are detailed in Figure 3 [29].

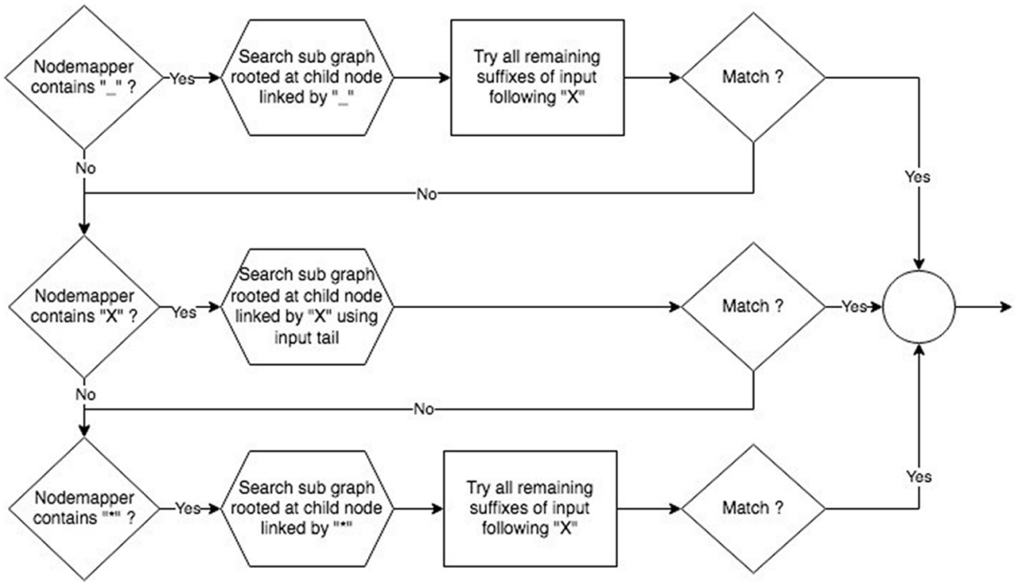

Fig. 3. Graph master pattern matching (source: www.alicebot.org)

C) *Chatbot Architecture*

The chatbot system consists of three entities: chatbot interface, chatbot back-end, and database. Each of these entities cannot be separated. The chatbot interface serves as an application interface used by the user, and the text messages sent by the chatbot user will be processed by the backend using a pattern of matching, taking data from the database. The chatbot architecture is depicted in Figure 4.

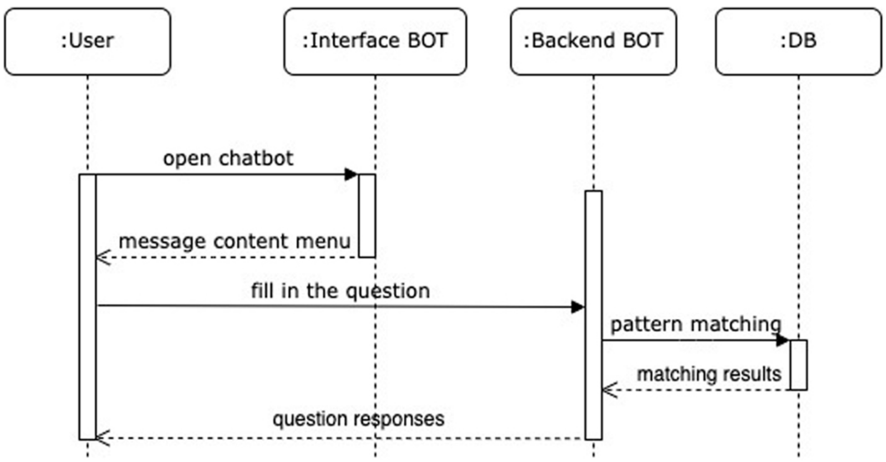

Fig. 4. Chatbot architecture

3.3 Post-game

A) *Application Demo*

The chatbot application test was conducted with 58 respondents, where each respondent interacted with the chatbot. However, not all respondents performed experiments on all existing topics. Tests conducted on 6 topics showed an average correct answer ratio of 93.1% out of a total of 251 questions, and a summary of the test results for each topic is presented in Table 3.

Table 3. Summary of the test results on each topic

	Topics					
	Salutation	Service Schedule	Health Information	Registration	Disease	Drug
Total Testing Topics	58	46	42	35	37	33
Correct Answer	58	42	39	34	32	30
Percentage of Correct Answers	100.0%	91.3%	92.9%	97.1%	86.5%	90.9%

Chatbots are designed to answer questions using the Indonesian language. Examples of chatbot test results are shown in Figure 5.

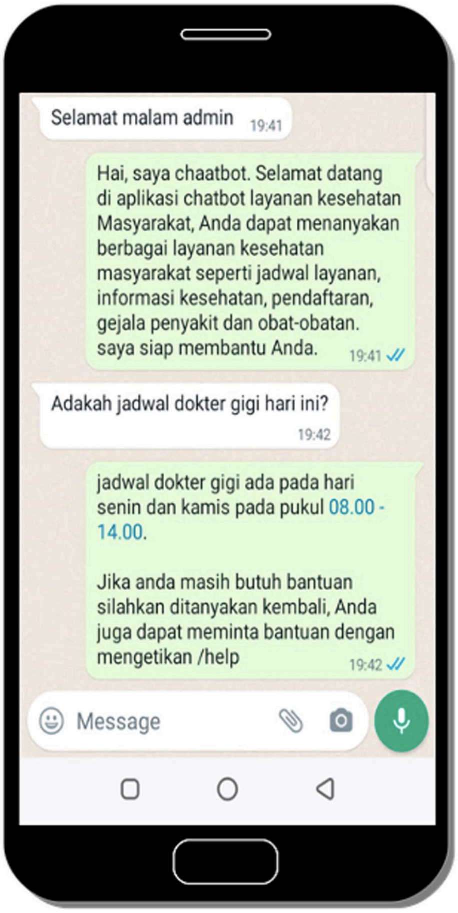

Fig. 5. The example of question and answer from chatbot

B) *Usability Measurement Results*

Usability measurement is done using the System Usability Scale (SUS). This method helps determine whether the system can be used properly [30]. Based on a thorough review of the collected data, the following points summarize SUS [31]:

1. SUS is dependable. Users consistently respond to the scale items, and SUS has been demonstrated to be more sensitive to variations than other questionnaires, even with smaller sample numbers.
2. SUS is accurate. In other words, it measures what it claims to measure.
3. SUS isn't a diagnostic tool. It doesn't explain what makes a system useful or not.
4. SUS scores return a value between 0 and 100, but they are not percentages The product's percentile ranking should be examined to determine how it compares to the competition.
5. SUS evaluates both usability and learnability. Although there is little association between SUS scores and task performance, it is not surprising that people's subjective evaluations may vary.

Figure 6 show grades for SUS performance.

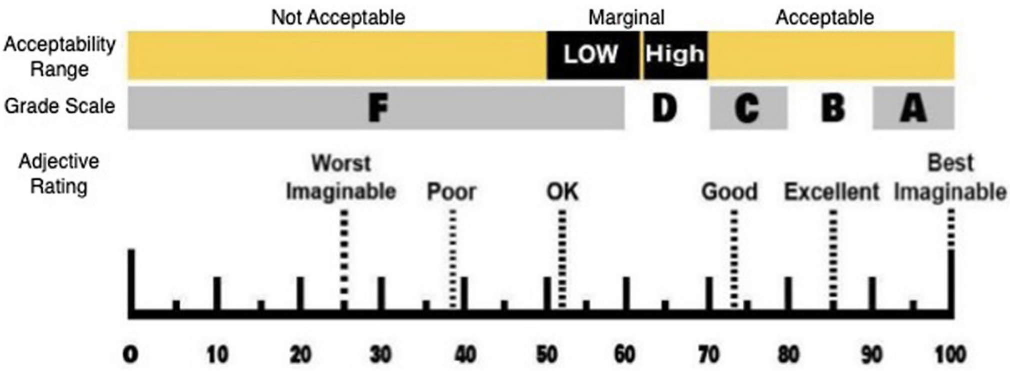

Fig. 6. Grades for SUS Performance

The usability measurement was carried out involving 58 respondents, with the characteristics of respondents shown in Table 4.

Table 4. Characteristics of respondents

Gender	Age	Total	Percentage
Male	15–25 26–35 36–45 46–55 >55	4 7 10 8 2	53.4%
Female	15–25 26–35 36–45 46–55 >55	5 12 6 3 1	46.6%

Based on the questionnaire results from 58 respondents, the measurement results of SUS are shown in Table 5.

Table 5. SUS Score

No	Question	Average Score
1	I think that I would like to use this chatbot frequently.	4.5
2	I found the chatbot unnecessarily complex.	1.9
3	I thought the chatbot was easy to use.	4.8
4	I think that I would need the support of a technical person to be able to use this chatbot.	2.0
5	I found the various functions in this chatbot were well integrated.	4.6
6	I thought there was too much inconsistency in this chatbot.	1.1
7	I would imagine that most people would learn to use this chatbot very quickly.	4.7
8	I found the chatbot very cumbersome to use.	1.1
9	I felt very confident using the chatbot.	4.9
10	I needed to learn a lot of things before I could get going with this chatbot.	2.5
	Total	32.1
	SUS Score (2.5 * Total)	80.1

From the results of the usability measurement on the chatbot app that has been built, an SUS value of 80.1 was obtained. This indicates that the developed chatbots are acceptable for use.

4 CONCLUSION

The study aimed to create chatbots based on artificial intelligence to support public health information services, addressing the difficulty of accessing information for individuals distant from health care facilities. The development of a chatbot was proposed as a solution. Several methods were considered for finding answers to user queries, including case base reasoning and brute force algorithms. However, the study opted to use the backtrack graph master pattern matching algorithm, employing a depth-first search strategy with Artificial Intelligence Markup Language.

The chatbots developed using the graph master pattern matching algorithm successfully interacted with users, resembling human interactions. The average success rate of correct answers reached 93.1% out of a total of 251 questions.

5 ACKNOWLEDGMENT

The research has been funded by the Ministry of Education, Culture, Research and Technology of the Republic of Indonesia on the University Applied Research Excellence Scheme in 2022.

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