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The Implementation of Fuzzy Logic Algorithm In Android-Based Typhoid Fever Diagnostic Application

Suryani[1)*], Ahyuna[2)], Magfirah[3)], Michael Oktavianus[4)], Erni Marlina[5)], Asrul Syam[6)], Faizal[7)]
[1)2)3)4)5)6)7)]Dipa Makassar University, Indonesia
[1)]suryani187@undipa.ac.id, [2)] Ahyuna@undipa.ac.id, [3)] s.si_magfirah@ymail.com, [4)]michael@undipa.ac.id,
[5)]ernimarlina@undipa.ac.id, [6)]asrulsyam12@undipa.ac.id, [7)]F41241@undipa.ac.id

ABSTRACT

Typhoid fever is an infectious disease that causes death in Indonesia. This endemic disease has a high incidence rate and is a health problem related to the environment and sanitation. Problems due to limited time to consult directly with specialist doctors, it is not easy to consult with doctors at any time, and limited medical knowledge and experience, so it is difficult for the community to know and make an early diagnosis of the disease with symptoms of typhoid fever. This study created an Android-based application using a fuzzy logic algorithm for diagnosing typhoid fever. The application was built by adopting expert knowledge related to general and clinical symptoms that are often experienced by patients with typhoid fever, and data on the level of typhoid disease. Data collection was carried out through direct observation at the hospital and direct interviews with doctors. The data was processed to produce output in the form of diagnostic results and solution data recommended by the system. The application consists of 3 user levels, namely Admin who can process user data, Users who can diagnose their disease by inputting answers to questions in the application, and Experts who can process symptom data, disease level, and solution data. The research results are in the form of an application that can be used anytime as an alternative consultant that helps the community in diagnosing typhoid fever with output in the form of diagnostic results (negative typhoid, positive typhoid, or strong positive typhoid).

Keywords: Typhoid fever; Diagnosis; Application; Android; Fuzzy Logic

1. INTRODUCTION

Typhoid fever or abdominal has been commonly encountered in people's lives in rural and urban areas, this disease is strongly influenced by personal hygiene and environmental sanitation such as food hygiene, slum environment, cleanliness of public places (restaurants and restaurants) and other behaviors that do not support healthy life. Typhoid fever is an acute infectious disease of the small intestine caused by the bacterium Salmonella Typhi, with symptoms of fever for more than a week which causing digestive disorders and can reduce the level of consciousness (Ardiaria, 2019). Symptoms of typhoid fever vary widely, initially fever with a gradual increase in temperature in the first three days, then continuous headache, flatulence and pain, anorexia, nausea, and constipation, then often followed by diarrhea, nosebleeds, apathy, and psychological symptoms (Rahimi et al., 2021). Typhoid fever in this application is divided into three levels,

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namely negative, weak positive, and strong positive. The symptoms of typhoid fever used in the application are 13 symptoms obtained from the results of interviews with expert doctors, these symptoms include: body temperature rises at night and falls during the day for 3 weeks, decreased appetite, excessive fatigue, pain in the muscles, abdominal pain, headache, constipation, diarrhea (black stools), diarrhea (bloody stools), nauseous, vomit, convulsions, and loss of consciousness.

To make a diagnosis of symptoms that resemble typhoid fever, you can do it by consulting directly with a doctor, carrying out examinations to laboratory checks including bacterial culture, serological tests that can be done such as Widal tests, ELISA, SD-PAGE blotting, RDT or POCT using venous blood samples, capillary blood, even serum, as well as typhidot, and Tubex TF, and other supporting examinations which can be characterized by leukocytosis and eosinopenia (Nurmansyah et al., 2020).

In addition to direct consultation and examination with a doctor, as an alternative, patients can use the Android application to diagnose the symptoms they are experiencing and find out whether the disease is typhoid fever or not. The android application is created using the Java programming language and can be implemented on a mobile platform. This application adopts expert knowledge, namely general practitioners. This knowledge is in the form of typhoid fever symptom data, disease level and solution data. The data goes through a process of knowledge acquisition, representation to computers, inference engines, to transferring knowledge to users, in this case patients or community users of the application.

The Fuzzy Logic method used in this study was Tsukamoto method, starting from the fuzzification stage, which is the first phase of fuzzy calculations, namely converting strict values to fuzzy values. Where each fuzzy variable is calculated for the degree of membership of each fuzzy set (Debora Mait et al., 2022). The representation of input and output membership values uses triangular and trapezoidal curves. The second stage is inferencing (rule formation), namely compiling a basis of rules in the form of fuzzy implications that state the relationship between input and output variables (Novia Rahma et al., 2020). The final step is defuzzification, which is changing the fuzzy set values into firm or crisp values. After obtaining the alpha-predicate value, the next step is the process of calculating the value of each consequence, each rule or z-value by dividing the alpha-predicate sigma value multiplied by z by the alpha-predicate sigma (Sinaga et al., 2021).

2. LITERATURE REVIEW

Some previous studies used fuzzy logic, namely (Sigani et al., 2019) with the title Expert System for Diagnosing Human Eye Diseases Using the Fuzzy Logic Method, which can diagnose 8 types of human eye diseases namely cataracts, trachoma, myopia, pterygium, conjunctivitis, asthenopia, glaucoma and hordeolum. The application allows the user to input symptoms and get treatment solutions using the fuzzy logic method. The application was built using the Visual Basic 6.0 programming language with 1 user level to diagnose human eye diseases. The application is used as a tool to display the results of human eye diseases diagnosis and treatment solutions according to the basic knowledge of an ophthalmologist.

Another related research was (Chasshidi & Putra, 2021) with the title Expert System for Diagnosing Pneumonia Using the Certainty Factor Method and WEB-Based Fuzzy Logic Tsukamoto. This application can diagnose pneumonia or also known as wet lung disease, which

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is an infection that attacks the lung tissue. The application diagnoses 2 levels of pneumonia, namely low and severe pneumonia. The fuzzy sets used were body temperature, leukopenia, and respiratory rate, PaO2, uremia and platelets. While the input symptoms used were 10 and produced pneumonia output with 4 levels of confidence, namely very sure, sure, fairly sure, and not sure.

Research by (Kurniati et al., 2019) can make an autism diagnosis based on the symptoms experienced by children with ADHD autism by having an uncertainty value with IARS rules represented by experts. The system provides knowledge about the early symptoms of autism in children for parents, it is hoped that it will be able to help parents to carry out initial treatment for children with autism, besides that teachers and psychiatrists can use the system in dealing with autism to facilitate patient examinations. The system built uses 3 variables, namely inattentiveness, hyperactivity, and impulsiveness. These three variables were presented in 35 questions that must be answered by the user.

Previous research was conducted by (Zamri et al., 2022) with the title Expert System for Diagnosing Gastritis and Appendicitis Web-Based. The research carried out the development of an expert system to detect ulcer disease and appendicitis in patients. The method used was the fuzzy logic method in analyzing the symptoms of the disease felt by the patient, so that they can find out the type of disease they are suffering from. The expert system of the fuzzy logic method can calculate the weight of all the answers entered by the patient. The highest result of the calculation indicates the highest probability of the patient experiencing the disease.

Previous research was also carried out by (Ismail et al., 2022) a Systematic Literature Review was carried out on several expert system journals that used the Fuzzy Logic method. The results of the study showed that the implementation of an expert system in diagnosing is very helpful for experts and practitioners. The knowledge base of a disease symptom can always be updated. Fuzzy Logic can diagnose diseases with accurate calculation results that are comparable to manual calculations, enabling fast and precise diagnosis.

3. METHOD

The system design used waterfall method. Waterfall describes the development of a model that presents the stages of system development. The waterfall stages consist of (Wahid, 2020):

a. *Requirement*, at this stage the researcher conducted an analysis of user needs for the software. The information needed was obtained through observation, interviews, library research, and direct surveys. Information was analyzed to obtain data on symptoms of typhoid fever, the level of typhoid fever and solutions.
b. *Design*, at this stage the researcher made a system design starting from the design of use case diagrams, class diagrams, activity diagrams, and application interface designs from the admin, user and expert sides.
c. *Implementation*, at this stage the researcher created a database system using MySQL then created integrated tables and implemented the Java programming language source code including the implementation of Tsukamoto method for processing input data.
d. *Verification*, at this stage the researcher verified and tested the unit and full system functionality.
e. *Maintenance*, at this stage the researcher run the system and made repairs if errors were found or unfound error in the previous stage.

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The method used to diagnose typhoid fever was Tsukamoto fuzzy logic method. The fuzzy method, or better known as the cryptic method, provides decisions that can provide values based on the number of variables. The sequence of the fuzzy calculation process is the formation of fuzzy sets, formation of rules, calculating rule predicates (α), Defuzzification (Ratama & Munawaroh, 2020).The fuzzy logic flowchart can be seen in Figure 1 below:

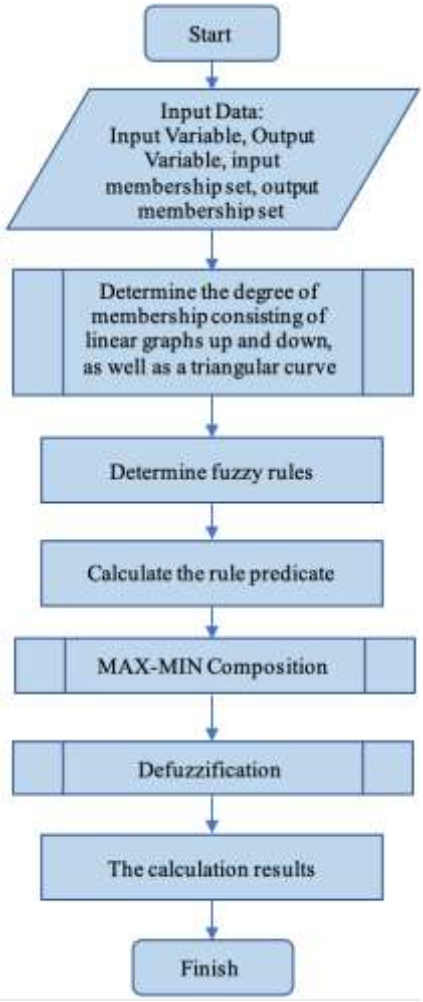

Figure1. *Fuzzy Logic Flowchart*

In Figure 1, fuzzy logic begins with determining the input and output variable data and the membership set to be used. Then the fuzzification process is to determine the degree of membership which has a value with a range of 0 to 1 and represents it in a linear, triangular, bell, trapezoidal or other curve. The next process is inferencing, namely the formation of rule-based fuzzy in the form of IF…THEN. Then calculate the predicate alpha from the rules that have been made based on the membership function. Next is the composition process of the max and min values from the results of the rule predicate. The next process is defuzzification, namely changing

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the fuzzy quantities presented in the form of fuzzy sets with their membership functions to get back a crisp value. This crisp will be used to determine the final result of a fuzzy logic.

The system testing method used was the black box testing method, black box testing is a method for checking whether there are errors or defects in the software to avoid a failure, testing is carried out on the outside of the software, such as application interface design (Parlika et al., 2020). This is also the reason for using black box testing because it is considered feasible to test the output of a software (Parlika et al., 2020).

4. RESULT AND DISCUSSIONS

Based on the results of system analysis and data collection through interviews with expert doctors, the symptom data used as input variables were 13 symptoms in diagnosing typhoid fever which can be seen in table 1, while the output variables were data on the level of typhoid fever which consisted of 3 levels namely negative, weak positive, and strong positive, can be seen in table 2.

Table 1. Symptom Data

No.	Symptom	Symptom
1	G01	Body temperature rises at night and falls during the day for 3 weeks
2	G02	Decreased appetite
3	G03	Excessive fatigue
4	G04	Pain in the muscles
5	G05	Abdominal pain
6	G06	Headache
7	G07	Constipation
8	G08	Diarrhea (black stools)
9	G09	Diarrhea (bloody stools)
10	G10	Nauseous
11	G11	Vomit
12	G12	convulsions
13	G13	Loss of consciousness

Table 2. Disease Level Data

No.	Disease Code	Disease Level
1.	P01	Strong Positive Typhoid fever
2.	P02	Positive Typhoid fever (weak)
3.	P03	Negative Typhoid *(negative)*

The fuzzy input variables used were 13 disease symptoms with each fuzzy set yes and no which has a value of 0 if the user answers no, it means they do not experience these symptoms, and a value of 1 if the user answers yes, it means they experience these symptoms. The fuzzy output variable in the application is the level of disease with 3 fuzzy sets, namely negative typhoid, positive typhoid, and strong positive typhoid, which is processed if it fulfills the predetermined

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fuzzy rules. In addition, the fuzzy output variable used was solution data, which is additional information as a follow-up to the diagnostic results.

Use case diagram is a diagram formed to describe the correlation between actor components and the system, which can be used to understand what activities occur in the system (Christian & Yusuf, 2022). The use case diagram for diagnosing typhoid fever application can be seen in Figure 2 below:

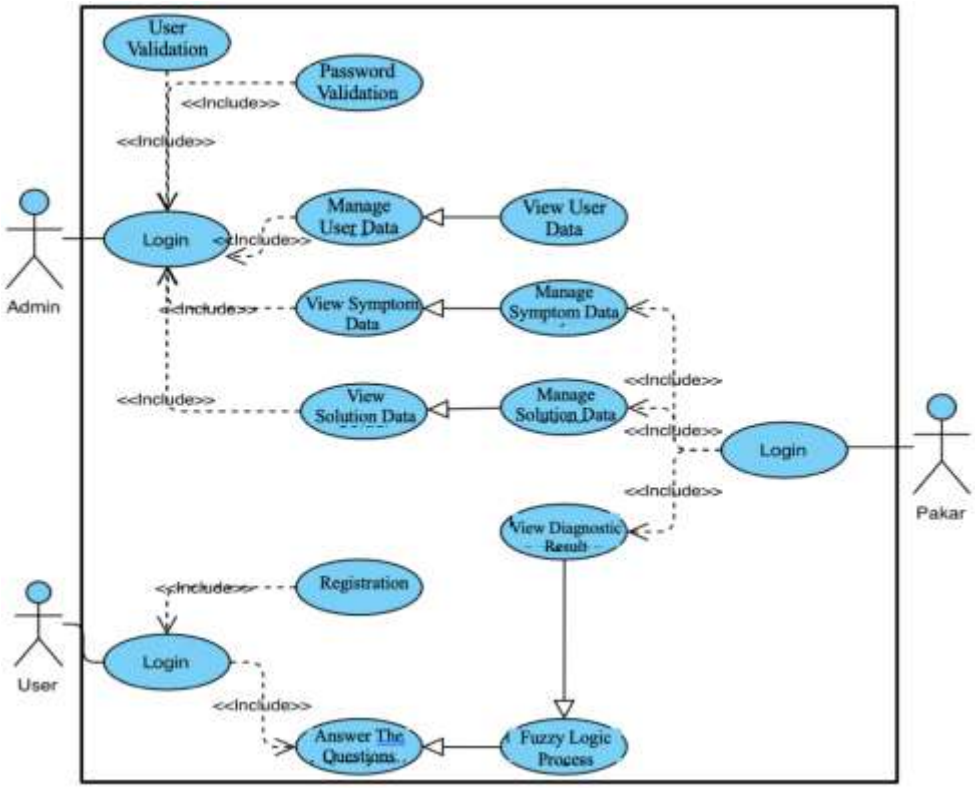

Figure 2. Use Case for Diagnosing Typhoid Fever Application.

In Figure 2, the application use case diagram consists of 3 levels access, namely admin, user, and expert. Admin has access rights to process user data, view symptom data and solution data. For the expert level, in this case the doctor has access rights to view user data and make changes to symptom and solution data, if needed at any time. In addition, doctors can also see the results of diagnoses from application users who have inputted their symptoms, namely answering questions presented in the application. The third access level is the users who will diagnose the symptoms of the disease they are experiencing, namely by giving answers to structured questions presented by the application. The users' answers will be recorded and processed using the Tsukamoto fuzzy logic method to produce diagnostic output in the form of the type of typhoid fever suffered.

Interface of the Android-based typhoid fever diagnostic application built includes:

a. *Interface* of User Main page in the following Figures 3:

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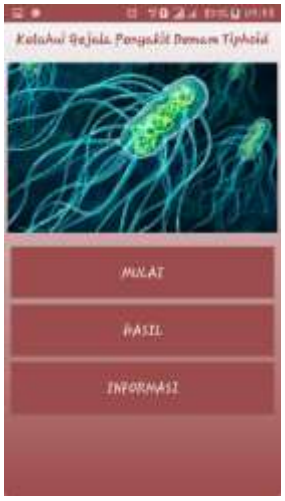

Figure 3. *User* Main Page

The main user page in Figure 3 consists of 3 buttons, namely to diagnose the disease by pressing the start button, the results button to find out the system diagnosis results of the symptoms experienced, and the information button to find out information related to typhoid fever.

b. *Interface* of Start Diagnostic in Figure 4 below:

Figure 4 *Interface* of Diagnosis

The diagnosis page in Figure 4 is a form for the user to answer questions provided by the system as many as 13 questions about the symptoms experiencing, for example, have you experienced a decrease in consciousness? The user must answer yes or no then proceed to the next question.

c. *Interface* of Symptom Data in Figure 5 below:

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Figure 5. *Interface* of Symptom Data

The symptom data page in Figure 5 is a form that can be accessed by the admin as well as experts, only the experts who can change symptom data, both adding, editing, and deleting symptom data. Existing symptom data corresponds to the input variables used as many as 13 symptom data presented in 13 questions.

d. Interface Data Solusi pada gambar 6 berikut:

Figure 6. *Interface* of Solution Data

The solution data page in Figure 6 is a form that provides additional information in the form of solutions based on the level of disease. In this study, the solution data was limited according to the number of disease stages as many as 3 data solutions.

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Table 3 below is the result of testing system functionality using black box testing:

Table 3. Result Testing

N	Testing	Something to be expected	Observation	Conclusi
1	Expert Login	The system will successfully login the expert page	Login successful	Succeed
2	*User* Login	The system will successfully login the user page	Login successful	Succeed
3	*Admin* Login	The system will successfully login the admin page	Login successful	Succeed
4	Diagnoses	The process of inputting symptoms by answering system questions	Process successful	Succeed
4	*Input* Symptom data	The symptom data input process was successful	Data saved successfully	Succeed
5	Edit Symptom data	The symptom data editing process was successful	Data saved successfully	Succeed
6	Delete symptom data	The process of deleting symptom data	Data saved successfully	Succeed
7	*Input* solution data	The solution data input process was successful	Data saved successfully	Succeed
8	Edit solution data	The solution data editing process was successful	Data saved successfully	Succeed
9	Delete solution data	The process of deleting solution data	Data saved successfully	Succeed

Based on the results of the system test using black box testing in table 3, the application made is declared free from errors.

4. CONCLUSION

Research on the Implementation of the Fuzzy Logic Algorithm in the Android-Based Typhoid Fever Diagnostic Application is in accordance with the initial goal to provide convenience to the community and patients, especially those who have symptoms of the disease, in diagnosing these symptoms whether negative, positive, or strong positive typhoid. If the application's diagnostic result is negative for typhoid, it means that the symptoms entered are not typhoid fever symptoms or it can be said that the patient has not detected typhoid fever. If the diagnosis is positive for typhoid, it means that the patient has a low level of typhoid fever, who must immediately carry out laboratory tests. And if the diagnosis is strong positive for typhoid, it means that the patient is infected with the bacteria that causes typhoid fever, so the patient is advised to immediately take further treatment at the hospital. In addition, the application made can be used as an alternative consultant for doctors who cannot be met for a while.

The Fuzzy Logic Algorithm was successfully implemented into an application to process input data in the form of symptom variables to produce solution data in the form of typhoid fever

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disease stages as a result of the application diagnosis. With this application, users can diagnose typhoid fever without visiting the hospital and consulting a doctor directly, thereby saving time and money. In the application made, development can be carried out by adding types of diseases that can be diagnosed with similar symptoms. So that the resulting output variables are more diverse. In the application, researcher can also add a medical record menu and a direct consultation menu with a specialist doctor by including a contact that can be contacted.

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