Using Certainty Factor Method to Handle Uncertain Condition in Hepatitis Diagnosis

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Abstract **-** The research aimed to develop a web-based application using the certainty factor. The use of this certainty factor method allowed processing the data based on the degree of confidence from the experts and the users. The users inputted their symptoms each with the level of confidence. The inference engine drew some conclusions based on the matching process between the input and the rules in the knowledge-based. For every matching pair, the system would calculate the certainty factor. The knowledge-based was developed through discussion with three specialist physicians and literature in some previous studies. The evaluation of the system involved three specialists for validation testing and 51 respondents for BlackBox testing. The final result is displayed in the form of a percentage for each hepatitis type, explanation of first aid for hepatitis, and referral hospital for hepatitis patients. The result shows that the error rate in the diagnosis process is under 36%. Most of the respondents think that the quality of the system is good overall.

Keywords: Certainty Factor method, hepatitis diagnosis

I. INTRODUCTION

In Indonesia, hepatitis has become one of the infectious diseases with a reasonably large number of patients. Based on the survey from Basic Health Research in 34 provinces in Indonesia (Kementerian Kesehatan Republik Indonesia, 2018), there was an incremental prevalence amount of hepatitis patients from 0,2% of the population in 2013 to 0,4% in 2018. This survey was conducted based on doctor diagnose. The worst risk for hepatitis patients who cannot be adequately cured is death. Hepatitis can be caused by a viral infection which can be divided alphabetically, namely A, B, C, D, and E virus. Moreover, alcohol, drugs, and chemicals can also be the cause of hepatitis (Novarina, Santoso, & Indriati, 2018; Kementerian Kesehatan Republik Indonesia, 2014). Someone that consumes much alcohol or drugs potentially has hepatitis.

Generally, hepatitis can be detected by visiting doctors, but this is usually can be done by the middle and upper-class society. Moreover, visiting doctors sometimes can be a problem for middle to lower class society. Financial reasons and ignorance about hepatitis are the reason they do not visit the doctor for a medical check-up. Therefore, by utilizing technological advances that have reached many aspects of life, the researchers can make a health care web-based application to help people making a diagnosis of hepatitis. For data processing, the application uses the Certainty Factor (CF) method. This method allows a conclusion or diagnosis, although there is an uncertainty in patient condition or uncertainty in the rules used to conclude (Sari, 2013; Gunawan & Wardoyo, 2018). CF can also describe the level of confidence of experts (the doctor) to the problems (Aji, Furqon, & Widodo, 2018; Nst, Mesran, Suginam, & Fadlina, 2017). It is by considering that a doctor often using the phrase ‘maybe, most likely, almost definitely,’ in making a diagnose. In short, CF is a value that shows the degree of confidence of an expert to assume the data (Aji *et al.,* 2018; Ratama, 2018). All of these theories make the CF method suitable for diagnosing uncertain things (Wulandari & Yuliandri, 2014). It can give more than one disease as a result based on their probability (Munandar, Suherman, &

Sumiati, 2012; Ramadhan & Pane, 2018). Previous researchers also show that CF method successfully provides high accuracy in detection of disease in a human or plants (Muludi, Suharjo, Syarif, & Ramadhani, 2018; Sevani & Chandra, 2016; Gunawan & Wardoyo, 2018; Ramadhan & Pane, 2018; Ratama, 2018; Halim & Hansun, 2015; Aji *et al.,* 2018).

The web-based application represents expert knowledge. It is expected to help people to know their health condition based on symptoms they feel. The result of the diagnosis can also be used as supporting data when the patients consult a doctor for further treatment (Halim & Hansun, 2015). Some applications use the CF method for diagnosing hepatitis (Pramana, 2012; Ramdhani, Isnanto, & Windasari, 2015; Susanto, Setiowati, & Helen, 2009). However, the application still requires input from other parties, such as blood tests, in addition to the physical symptoms. These applications also cannot give a referral hospital for the treatment.

Based on the conditions mentioned, the researchers analyze how to make the web-based application that can diagnose hepatitis disease by applying the CF method. The goal of the research is to make a web-based application for diagnosing hepatitis using the CF method. It is expected in the long term that the application can help all classes in society to make early detection of hepatitis independently.

II. METHODS

The diagnosing process in the research adopts the knowledge and the ways of a physician in diagnosing the patient. In the development process, it is necessary to make acquisition and representation of knowledge from the physician. Figure 1 is the stages of application development to diagnose hepatitis using the CF method.

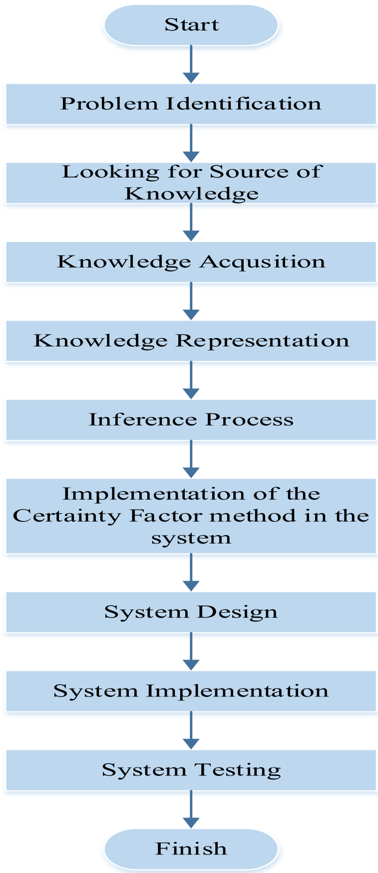


Figure 1 The Stages of the Research

The first step is problem identification. In this case, problem identification is in the diagnosing process of the hepatitis domain. The second step is looking for a source of knowledge. The research uses tacit knowledge obtained from the physician as the primary source. The third step is the knowledge acquisition process. The acquisition of knowledge is a crucial process to create and manage the knowledge from the external environment through active communication (Dahiyat, 2015). The acquisition of knowledge is done by searching the predecessor sources or studying some literature about the implementation of CF. In the research, the researchers also conduct discussions and interviews with three specialist physicians to gather information about the types and symptoms of hepatitis.

The data and information obtained from the expert are used to build knowledge. The data and information cover the symptom and type of hepatitis. The information also includes CF value for each symptom based on the confidence level of the expert during the acquisition process.

The fourth step is the representation of knowledge. The goal is to encode the acquired knowledge in the knowledge base into the computer program. This research uses the rule for knowledge representation. The rule can be used to explain many types of complex statements. It is usually suitable for the reasoning process of the concrete data (Jain & Mishra, 2014).

The rule is written in the if-then form. It contains data as a condition and action to be executed according to the matching process. It searches the suitability of the condition in the rule with the user's answer. If there is a rule that matches the users' answers, the system will execute the action of the rule automatically. The matching and executing processes of the rules stop if the system does not find the match condition in the existing rules. The inference engine does this process.

The fifth step is the inference process. The inference engine is the 'brain' of the expert system. This engine conducts the matching process and makes some conclusions. The conclusion is drawn from the action of a rule that matches the users' answers. This research uses a forward chaining technique. In forward chaining, the matching process will begin with collecting all the users' answers related to the fact listed in the rule. This process is often called as data-driven. For every matching fact (premise), the engine executes the action to obtain a hypothesis.

The sixth step is the implementation of the CF method. It is carried out simultaneously with the inference process. There are several steps to implement CF. First, the researchers determine the value of CF from the expert for all the symptoms of hepatitis. The CF value is acquired through discussion and interview with the expert. Second, the researchers specify the rule that will be used for the calculation of the CF method. Third, it is the determination of the answer value of CF from the users. The users are given the option of the answer value when they use the system.

Fourth, the researchers multiply the CF value from experts and users. It is to get the value of CF symptoms using Equation (1) as follows:

$$\mathrm{CF}\,[\mathrm{H},\mathrm{E}]_1 = \mathrm{CF}\,[\mathrm{H}] * \mathrm{CF}\,[\mathrm{E}] \quad (1)$$

CF is the factor of the hypothesis (H). It is influenced by the fact (event (E)). CF [E] is the evidence of CF in E. Meanwhile, CF[H] is the evidence of CF in H.

Fifth, the results of CF symptoms of the fourth step are combined using Equation (2) as follows:

$$\mathrm{CF}combine\,[\mathrm{H},\mathrm{E}]_{1,2} = \mathrm{CF}\,[\mathrm{H},\mathrm{E}]_1 + \mathrm{CF}\,[\mathrm{H},\mathrm{E}]_2 * (1 - \mathrm{CF}\,[\mathrm{H},\mathrm{E}]_1) \quad (2)$$

If the value of CF symptoms is more than two, the researchers use Equation (3) to find the value of CF old. The equation is as follows:

$$\mathrm{CF}combine\,[\mathrm{H},\mathrm{E}]_{old,3} = \mathrm{CF}\,[\mathrm{H},\mathrm{E}]_{old} + \mathrm{CF}\,[\mathrm{H},\mathrm{E}]_3 * (1 - \mathrm{CF}\,[\mathrm{H},\mathrm{E}]_{old} \quad (3)$$

Sixth, the researchers change the result of the fifth step by using Equation (4) to get the presentation value. The equation is as follows:

$$Percentage\ confidence = \mathrm{CF}combine * 100\% \quad (4)$$

The seventh step is system design. The research uses some diagrams to simplify the design and analysis process. The diagrams used in this process are the flowchart, use case diagrams, database design, and user interface. The flowchart is used to describe the workflow of the system. Meanwhile, use case diagrams describe the interaction between actors with the system. Then, the design of the database is used to store data that are logically connected with the description of the data.

The eighth step is system implementation. The application for the detection of hepatitis disease is created using the Bootstrap Design Framework. The PHP and MySQL software are also used as the programming language and the database respectively.

The last step is the system evaluation process. The researchers tests the developed application. Black-Box and White-Box testing are used to test the application.

The goal of Black-Box testing is to try the usability of all functions of the system. The tester of Black-Box testing does not know the details of the system. It is done by demonstrating the application and distributing questionnaires to 51 respondents. They directly participate in the demonstration. The researchers use the random sampling method to choose the respondents. The questions are a simple version of the questions used by Sevani, Putro, and Marpaung (2016) in the usability testing for the web-based system.

Meanwhile, White-Box testing is performed by system developers to find possible bugs or errors in the application logic. It is done by trying all the menu, function, and link in the system and comparing the result with the diagram made in the design process. The validation testing is also conducted to validate the output of the system. Three specialist physicians conduct it. The error rate is calculated based on the comparison between the output of the application and the diagnosis result from the physicians.

III. RESULTS AND DISCUSSIONS

To use the system, the user needs to login using a username and password. The user only needs to register once to get the username and password. After logging in, the user is asked to answer some questions, including choosing the CF value. Then, the inference begins by matching the user's answer with the condition of the rules and calculating the CF combination value. The system will display the final result in a percentage format and also explain the result, such as the type of hepatitis suffered by the user, treatment advice, and the referral hospital. The flowchart of the system can be shown in Figure 2.

There are two actors in the system, namely the user and the admin. The user is a member of the society or a patient who will do the detection process. Meanwhile, the admin is a person who will maintain the system. The admin can be a doctor or someone who has knowledge about hepatitis and is familiar with using a computer application or website. Both actors have different permissions, as shown in Figure 3. The detail explanation of the permissions of each actor is in Table 1.

Table 1 The Explanation of the Use Case Diagram

Use case: Hepatitis Diagnosis System
Actor: User and Admin
Pre-Condition: User and Admin will use application
Post-Condition: User and Admin already use the application

Description: User can use all the functions provided by the application, except viewing and deleting user data, entering the hospital data, editing and deleting, and registering admin/user. Admins can use all functions provided by the application, including diagnosis, view and edit diagnosis result, and edit and delete user's data profiles and hospital list.

User	Admin	System
1. User needs to register first. 2. User can not run a hepatitis diagnosis feature before logging in. 3. User must enter the email and password to log in so that it can enter the hepatitis diagnosis page. 4. User will do re-login by entering the email or password 5. After the successful login, the user can use the hepatitis diagnosis feature, see the diagnosis, clear the diagnosis, view and edit the users' profile, and see the list of hospitals.	1. Admin must register first. 2. Admin must enter the email and password to log in so that she/he can access the existing functions in the admin page. 3. Admin performs a re-login by entering an email or password. 4. Once logging in, admin can select several functions such as viewing diagnosis, viewing and deleting user data, inputting the hospital (edit and delete), viewing the hospital, and registering the admin/user.	1. The system will not find the user's data or admin if there is no registration. 2. The system will perform validation when a user or admin logs in. 3. The system will display a message to the user or admin and is back to the login page if the validation during logging in is unsuccessful. 4. The system will display a message if the login is successful and go to the homepage of the user or admin. 5. The system will bring the user and admin to the selected page.

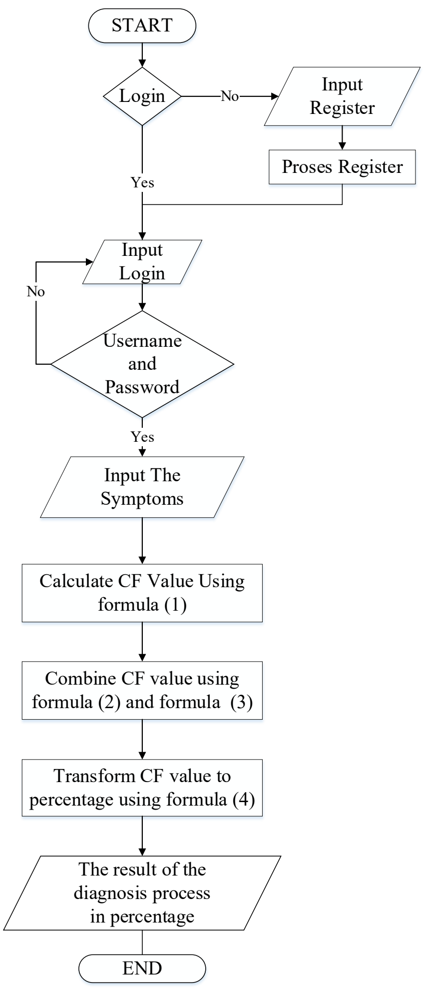


Figure 2 Flowchart of the System

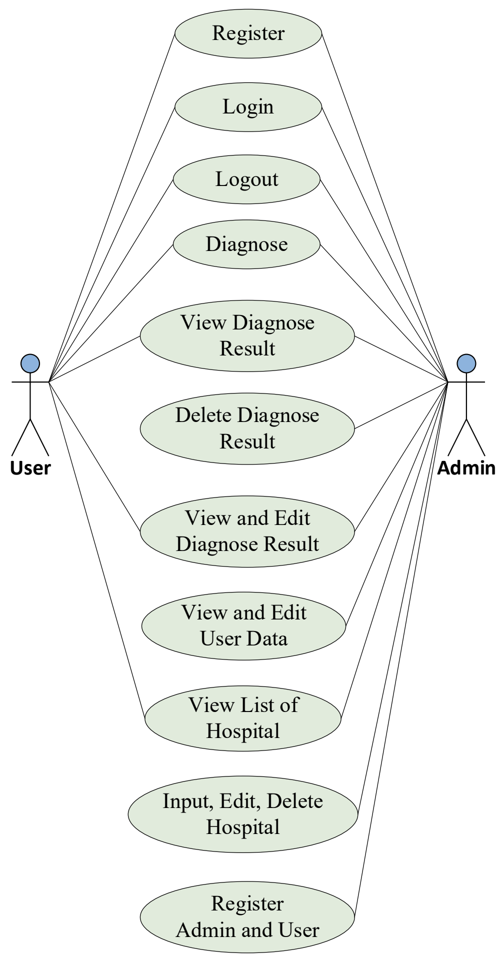


Figure 3 Use Case Diagram of the System

Then, the system makes the diagnosis based on the knowledge base built in the earlier stages of the research. Tables 2−4 are the knowledge base. The information is obtained as a result of knowledge acquisition. Table 2 shows the types of hepatitis. Then, the data of hepatitis symptoms with their CF are in Table 3. Meanwhile, Table 4 shows the CF values that represent users' uncertainty about their condition. It can be selected by the users every time they answer the questions from the system (Setiabudi, Sugiharti, & Arini, 2017).

Table 2 Type of Hepatitis

Code	Type of disease
P01	Hepatitis A
P02	Hepatitis B
P03	Hepatitis C

Table 3 Symptoms of Hepatitis

Code	Symptom	CF Specialist / Weight
G01	Fatigue	0,1
G02	Nausea	0,1
G03	Throwing up	0,3
G04	Diarrhea	0,2
G05	Fever	0,2
G06	Joint pain	0,3
G07	Muscle ache	0,3
G08	Itchy	0,1
G09	Loss of appetite	0,3
G10	Losing Weight	0,4
G11	Pain in the liver area	0,6
G12	Yellow skin and eyes	0,8
G13	Dark-colored urine	0,7
G14	Gray Feces	0,7
G15	Stomachache	0,1

Table 4 Data Value of Assurance User

No.	Information	User value
1	Really do not know	0
2	Do not know	0,2
3	Slightly sure	0,4
4	Sure enough	0,6
5	Sure	0,8
6	Very sure	1

Based on the results of knowledge acquisition, the researchers make the rules. Three rules are used in this application. Those are as follows:

Rule 1: IF G01 AND G02 AND G03 AND G04 AND G05 AND G06 AND G07 AND G08 AND G09 AND G010 AND G013 AND G014
AND THEN G015 P01

Rule 2: IF G01 AND G02 AND G04 AND G05 AND G06 AND G08 AND G09 AND G010 AND G011 AND G012 AND G013 AND G015 THEN P02

Rule 3: IF G01 AND G02 AND G03 AND G04 AND G05 AND G06 AND G07 AND G09 AND G011 AND G012 G014 AND THEN P03

The calculation uses the CF equation and knowledge base in the system. The calculation process implemented in the system is according to the steps mentioned previously. For example, the user states that there are four symptoms experienced (G03, G06, G014, and G015), and based on the existing rules in the knowledge base, it can be concluded that the user suffers the symptoms of hepatitis A, B, and C.

Based on Table 3, the researchers can see that the CF value of each symptom from the expert are G03 = 0,3; G06 = 0,3; G14 = 0,7; and G15 = 0,1. User answers that he/she has four symptoms which each the symptom has CF value of G03 = 0,6; G06 = 0,4; G14 = 1; and G15 = 0,8.

Then, the CF combination value is calculated by multiplying the CF value from an expert with the CF value from the user using Equation (1). The result for the four symptoms written sequentially are 0,18, 0,12; 0,7; and 0,08. All values obtained from CF and symptoms will be combined using Equation (2). It gets the result of 0,2784, which will be saved as $CFcombine_{1,2}$ or $CF_{old\ 1}$.

Next, the calculation is continued using Equation (3). The result is 0,78352 and saved as $CFcombine_{old\ 1,3}$ or $CF_{old\ 2}$. By repeating the fourth and fifth steps in the implementation of the CF method, the researchers finds the value of CF old. The final old value obtained is 0,8008. Then the old value will be converted to the percentage using Equation (4). The value of the confidence of user is 75,4% (diagnosed with hepatitis A (P01)), 19,04% (diagnosed with hepatitis B (P02)), 80,08% (diagnosed with hepatitis C (P03)). It can be concluded that users are exposed to hepatitis C (P03).

Figures 4 and 5 are examples of the existing system interface. Figure 4 contains the questions to make the diagnosis. Users must answer the questions by choosing one of the answers that most reflect their condition. All answers will be calculated using the CF equation to produce final results. The final result is presented in the form of a percentage. It indicates the level of confidence of the disease according to the user's answer.

Moreover, Figure 5 shows the interface of the diagnosis results in graphical form. The result also includes treatment advice according to the type of hepatitis. The system also gives the user some information about referral hospital that provides services for hepatitis patient.

The researchers conduct three tests. Those are Black-Box testing, White-Box testing, and validation testing. The Black-Box testing is to test the usability (ease-of-use and users' perceptions) of all functions of the application. It is done by asking 51 respondents that already try the system (Niranjanamurthy, Nagaraj, Gattu, & Shetty, 2014; Setiabudi *et al.,* 2017; Sevani *et al.*, 2016; Wulandari & Yuliandri, 2014).

The researchers use the questionnaire as a tool to collect the respondent's results. The questionnaire forms are created by Google Form. It is distributed as an online survey. The questionnaire contains four questions related to the usability of the application (Sevani *et al.,* 2016). The system saves the response for further improvement. Figure 6 shows the result of the questionnaire.

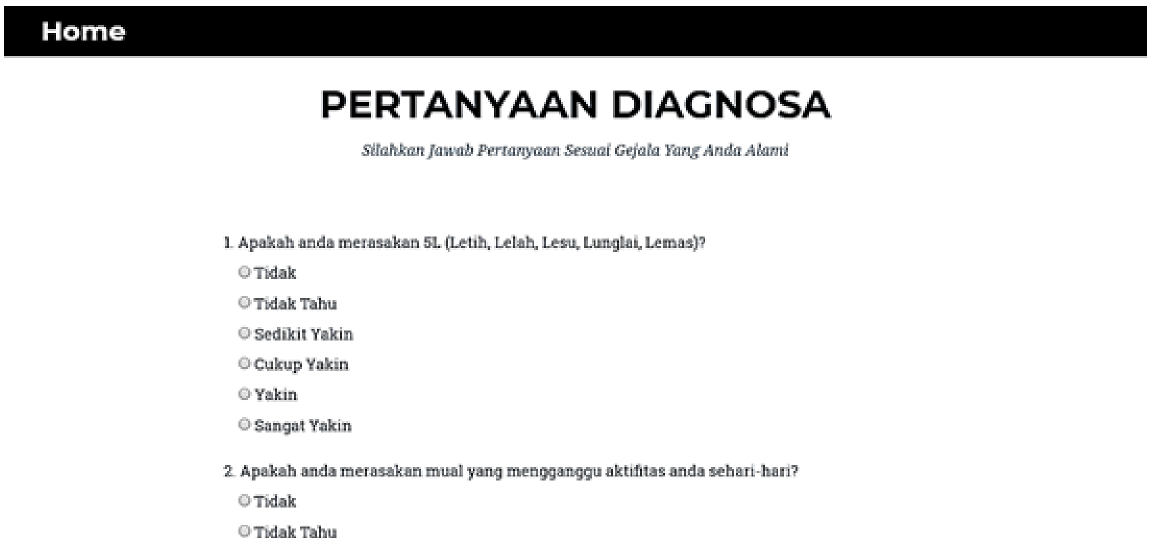
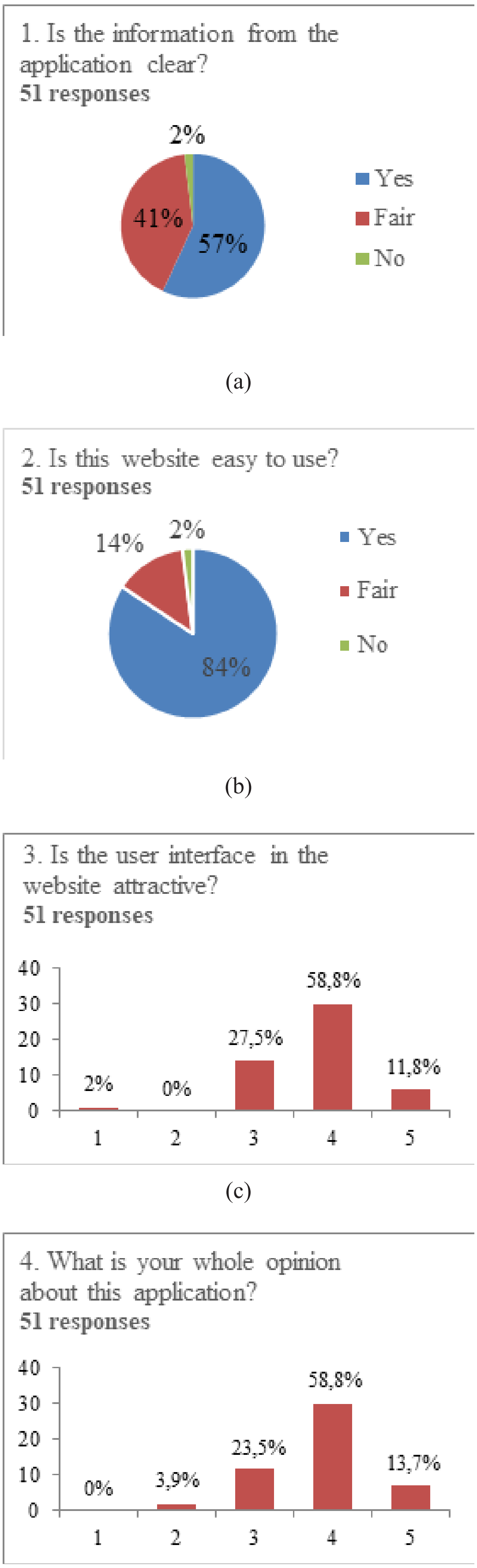


Figure 4 The Interface of the Diagnosis Menu

Figure 5 The Interface of the Diagnosis Results



(a) (b) (c) (d)

Figure 6 The Results of the Questionnaire

The first question is about the quality of the information provided for the user. The result has shown that there is 56,9% of users who answer good, 41,2% (sufficient), and 2,0% (not good), as displayed in Figure 6(a). The second question is about the ease of use as seen in Figure 6(b). About 84,3% of users answer that the system is easy to use. Then, 13,7% of the users agree that it is sufficient, and 2,0% of users state that the system is difficult to use.

The third question in Figure 6(c) is about the appearance of the system. About 2% of users answer that the interface is not good. Then, 27,5% agree that they are neutral, and 58,8% say that it is good. However, only 11,8% mention that the interface is very good. The fourth question in Figure 6(d) measures the overall quality of the system. The result shows that 3,9% of the users answer that the system is not good. About 23,5% are neutral, 58,8% say that the system is good, and 13,7% mention that the system is very good.

In White-Box testing, the system will be tested based on two types of actors (user and admin). The White-Box testing is to test some function of the system (the logic). The result is shown in Table 5. The examination column describes the testing action. Meanwhile, the expectation column describes the expected result, and the reality column shows the real result of the examination. The result column shows whether the action is successfully conducted or not. It means that there are no different results between expectation and reality.

The researchers also conduct validation testing by matching the system output with the opinion of the physician as an expert. There are three physicians involved as the tester of the system. Then, there are 40 test data obtained randomly. Due to time constraints, each physician only can validate about 15 test data. The comparison between system output and the opinion of the expert can be seen in Table 6. The results of the calculation error by the expert are done as follows:

$$Error\ level\ for\ the\ first\ expert = \frac{the\ number\ of\ different\ result}{s\ the\ total\ number\ of\ the\ testing\ data} * 100\% = \frac{5}{14} * 100\% = 35{,}7\% \quad (5)$$

$$Error\ rate\ by\ the\ second\ expert = \frac{the\ number\ of\ different\ result}{s\ the\ total\ number\ of\ the\ testing\ data} * 100\% = \frac{3}{14} * 100\% = 21{,}4\% \quad (6)$$

$$The\ error\ rate\ by\ the\ third\ expert = \frac{the\ number\ of\ different\ result}{s\ the\ total\ number\ of\ the\ testing\ data} * 100\% = \frac{4}{12} * 100\% = 33.3\% \quad (7)$$

Overall, there is no significant difference between the proposed system with the existed system. The main difference is in the list of referral hospitals provided by the proposed system. This system hopefully can help the users to get further assistance in the treatment of hepatitis.

Table 5 The Result of White-Box Testing

Actor	Examination	Expectation	Reality	Result
User	Fill the registration form	All the fill-in data will be saved in the database, and the user returns to the login page	All the fill-in data will be saved in the database, and the user returns to the login page	Success
	Fill at least one field in the registration form with the wrong format data	The user cannot submit the registration form and stay on the registration page. There will be an error message	The user cannot submit the registration form and stay on the registration page. There will be an error message	Success
	Log in as a registered user and want to access the diagnostic page	Go to the diagnostic page	Go to the diagnostic page	Success
	Log in with wrong email or password	The users stay in the login page, and an error message appears	The users stay in the login page, and an error message appears	Success
	Finish perform diagnostic in the diagnostic page	The result is saved in the database, and the user goes to the result page	The result is saved in the database, and the user goes to the result page	Success
	View detail or history of the diagnostic result	Go to the result page, and the desired result will appear	Go to the result page, and the desired result will appear	Success
	Edit user profile	Go to the profile page and edit the profile according to the user logging in	Go to the profile page and edit the profile according to the user logging in	Success
	Change password	Input the new password, check the old password in the database, and update the database with the new password	Input the new password, check the old password in the database, and update the database with the new password	Success
Admin	Log in with correct data	Go to the admin page	Go to the admin page	Success
	Log in with incorrect data	Stay in the login page, and an error message appears	Stay in the login page, and an error message appears	Success
	Add new admin/hospital/ suggestion	Input the data for the new admin/ hospital/suggestion, and check the new data with existing data in the database. If the new data is different from the existing data, and the data format is correct, the new data will be saved in the database. Then, a confirmation message will appear and go to the admin page. Otherwise, it stays on the same page, and an error message appears	Input the data for the new admin/ hospital/suggestion, and check the new data with existing data in the database. If the new data is different from the existing data, and the data format is correct, the new data will be saved in the database. Then, a confirmation message will appear and go to the admin page. Otherwise, it stays on the same page, and an error message appears	Success
	Edit data of admin/hospital/ suggestion	Go to the admin's profile/list hospital/ list suggestion page. The admin can edit the profile according to the admin logging in/hospital/suggestion. If the format for the new data is correct, the old data will be updated with the new one. Then, the confirmation message appears and goes to the admin page. Otherwise, it stays on the same page, and an error message appears	Go to the admin's profile/list hospital/list suggestion page. The admin can edit the profile according to the admin logging in/ hospital/suggestion. If the format for the new data is correct, the old data will be updated with the new one. Then, the confirmation message appears and goes to the admin page. Otherwise, it stays on the same page, and an error message appears	Success
	Delete data of admin/ hospital/ user/suggestion	Choose the admin/the hospital/the user/the suggestion to be deleted. A confirmation message appears.	Choose the admin/the hospital/the user/the suggestion to be deleted. A confirmation message appears.	Success

Table 6 Comparison between System Output and the Experts' Decision

Physician	Comparison between System & Expert		Total Case
	Same Result	Different Result	
Physician 1	9	5	14
Physician 2	11	3	14
Physician 3	8	4	12

IV. CONCLUSIONS

Based on the results of the implementation and evaluation, it can be concluded that the CF method can be implemented in the hepatitis diagnosis. This method works based on the symptoms experienced by the users. It also provides results of the type of hepatitis with the percentage. It describes the certainty of the system about the possibility of the disease. The error rate is in the range of 20%−35%. It means that there are still many discrepancies between system output and the opinion of the system. However, the Black-Box testing results show that the system has a good usability value. Moreover, all functions work well as they should be.

The contribution of this research is to increase the number of applications in the medical field, especially for hepatitis diagnosis. The implication of the research, in the long run, it can increase public awareness to care about their health condition since the early stage. Moreover, the limitation of this research is related to the method used to handle the uncertainty by using only one single method. Another limitation is related to the source of knowledge, which is limited to the number of experts.

For future research, it is recommended to minimize the error value by evaluating the CF value from the experts and produce more detailed rules for each of the hepatitis type. Using more data testing for each expert can also be considered for validation testing. Besides, in usability testing, the research can add more indicators to get a detailed response from the users.

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