COVID-19 Disease Diagnosis Expert System with Certainty Factor Method using iOS-Based App

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***Abstract*— The drop in COVID-19 patients in Indonesia from January to February 2022 made many companies prepare policies to no longer enforce work from home. At the office, we can interact and meet other people directly and it is possible to be exposed to Covid-19 that could potentially become a new wave of COVID-19. This effect poses a serious risk to all people who come into contact with COVID-19-infected individuals or are close to them. The major course of action that may be performed when someone has COVID-19 is self-isolation and tracking anyone who is around or has a health condition associated to COVID-19. We require an iOS-based COVID-19 diagnosis expert system application to track the health status of everyone around us because we are unable to know the health status of everyone. The application uses artificial intelligence technology in the form of an expert system to check health conditions. The expert system replaces the role of the expert with the certainty factor method. This app should be used every time before entering a potentially crowded place to clarify tracking by using maps feature. In addition to COVID-19, this expert system can also diagnose diseases that have the same symptoms as Typhoid Fever and Pneumonia. The results of the expert system are in the form of diagnosing the user's health condition based on the symptoms given with a confidence level of up to 0.9999952130944 or 99.99952130944% for COVID-19, 0.9676 or 96.76% for Typhoid Fever, and 97% for Pneumonia.**

Keywords*— *COVID-19, Artificial Intelligence, Expert System, Certainty Factor, iOS, Maps.

I. INTRODUCTION

The number of positive confirmed cases of COVID-19 has been used as epidemic data (contagion) and international groups of experts, with various fields of scientific expertise, have been working with China to try to control the outbreak [1]. The approach used for COVID-19 cases requires a monitoring system, besides that it can also be in the form of a survey design for each positive patient to ensure the number of people is increasing with common symptoms, such as urinary tract infections. acute respiratory infection (ARI). Data on the distribution of ARI symptoms and the percentage of positive patients can be used as information on estimates of epidemic cases in the region [2].

The current era of digital technology is the time to put in place digital infrastructure to monitor these global health cases. Electronic reporting will increase the efficiency of these and other public health studies that involve testing directly in the field [2]. The symptoms of COVID-19 are mostly non-specific (uncertain) such as fever, cough, myalgia (muscle pain), weakness/lethargy, diarrhea, and nausea a few days before the fever. Multiple headaches and hemoptysis (coughing up blood), even relatively asymptomatic for some cases [3]. Emergency warning signs of having COVID-19 include severe difficulty breathing, continued pain or pressure in the chest, confusion or inability to rise, and bluish lips or face [4].

This technology is very helpful in all aspects such as data archiving and information media. One of the current technological trends is an expert system. An expert system is a computer-based system that uses knowledge, facts, and reasoning techniques in solving problems that are usually only solved by an expert in a particular field [5]. An expert system with MYCIN is one solution for medical purposes in terms of diagnosing a symptom and pain [6].

Referring to the description above, this research will attempt to reveal how to diagnose someone affected by COVID-19 disease using an application that utilizes an iOS-based expert system, as well as knowing the spread of COVID-19. According to [7] the expert system is expected to be able to diagnose disease by analyzing the symptoms of the disease into a decision by using the forward chaining method as the tracking method and the certainty factor method as a method to calculate the confidence value of the symptoms given by the user.

The research conducted by [8] has a theme that is close to the same as the research to be carried out, but still has several differences, namely:

TABLE I
DIFFERENCES IN VARIOUS ASPECTS FROM PREVIOUS RESEARCH

Differences	Previous Research	Current Research
Operating System	Android	iOS
Database	None	MySQL Remote
COVID-19 Information	In general and only numbers	In the form of a map with a WiFi radius for app users, so the other users can track
Diagnose History	None	There is diagnose history
Personal Data	None	There is an account for each user so that history and personal data can be monitored

the author has contributed greatly in completing this research, ranging from literature studies on COVID-19 in the health department and from book [9], application planning and design, application coding, testing and evaluation, to reporting and writing this paper.

II. METHOD

This study aims to design and create an iOS-based COVID-19 diagnosis expert system application. To get the results of the expert system diagnosis, we use reasoning techniques to determine a decision. Reasoning techniques are able to implement existing problems into the knowledge base and perform a series of logical processes (reasoning) to obtain solutions. An example of the implementation of the reasoning technique is the expert system in medicine [10]. Therefore, the research method used is the certainty factor, namely the certainty factor found from results that do not contain full certainty of expert questions (experts).

This method is used to provide answers to uncertainty answers caused by uncertain rules and uncertain user answers to a question posed by the system. An expert (for example, a doctor) often diagnoses the information contained in the patient with the expressions "most likely", "probably", "almost certain"[3]. So that this can be overcome, the solution is to use a certainty factor (CF) in order to explain the level of expert confidence in the problem at hand [3]. The development of science and technology helps human work, which is wrongly based on knowledge with assistance [11].

From the certainty factor method, this study uses qualitative research, which is to calculate data in the form of symptom weights given by experts which are then processed using the certainty factor method on an iOS-based COVID-19 diagnosis expert system. For coding, the author used flutter and execute the code with Xcode which can be used to manage the entire development workflow from building apps to testing, optimizing, and submitting them to the App Store [12].

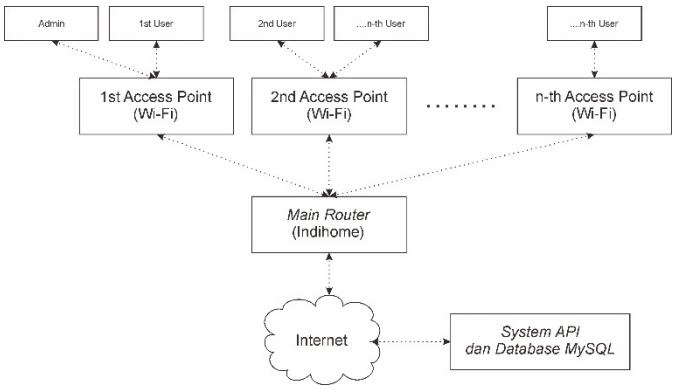

Figure 1. System block diagram

Certainty Factor uses the certainty value to assume the degree of confidence of an expert on the value of each symptom in the expert system. This method uses a calculation based on the similarity divided by the weight that has been determined by the expert. The CF method shows a measure of certainty about a fact or rule. CF is also a clinical parameter used to describe the magnitude of a belief.

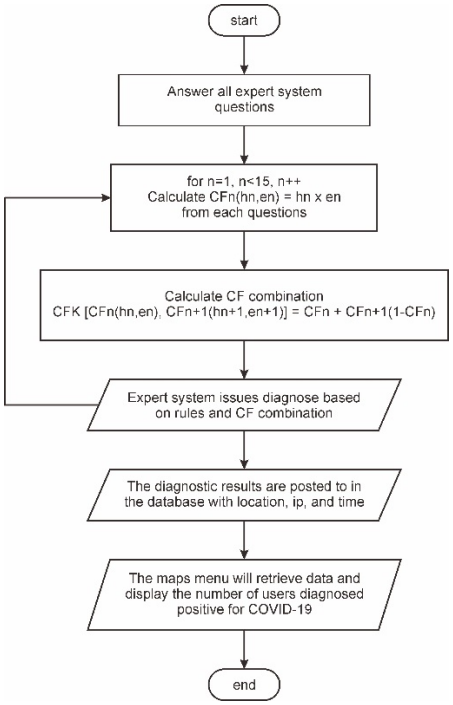

Figure 2. System block diagram

The calculation used is the calculation of a combination of two or more rules with different facts or symptoms but in the same hypothesis/rules [13].

$$\text{Symptom 1 } CF(h, e1) = CF1 = C(e1) \text{ x } (CF\ h1) \quad (1)$$

$$\text{Symptom 2 } CF(h, e2) = CF2 = C(e2) \text{ x } (CF\ h2) \quad (2)$$

$$\text{Combination } CF[CF1, CF2] = CF1 + CF2\ (1 - CF1) \quad (3)$$

Information:
e = Evidence or value of symptoms experienced by users (0/1)
h = Hypothesis or conclusion value ranging from 0 to 1
CF(h,e) = Certainty Factor value by multiplying e and h

III. RESULTS AND DISCUSSION

The system calculation process will use the calculation formula number (3), namely the combination CF equation because there is more than 1 symptom in the rules that have been set by the expert. In this expert system, the value for the user's CF will be worth 1 if you answer 'yes' and will be worth 0 if you answer 'no'. Then the user's CF will be multiplied by the expert's CF according to the answers and symptoms that have been answered by the user so that the CF(h,e) is obtained. Then, the system will continue the calculation with the calculation formula number (3).

A. User answers all questions with 'yes'

Referring to tables II to IV, we can find the CF value (h, e) by multiplying all the expert CF values by 1, because the user answered all the symptoms with 'yes'. Then, enter the value of

CF(h,e) into the rules for the disease COVID-19, Pneumonia, and Typhoid Fever.

TABLE II
CALCULATION OF CF(H,E) FOR ALL SYMPTOMS ANSWERED 'YES' TO THE COVID-19 RULES

Symptom's Code	CF Expert	CF User	CF(h,e)
IF G01	0.7	1 (yes)	CF1 = 0.7
AND G02	0.7	1 (yes)	CF2 = 0.7
AND G03	0.5	1 (yes)	CF3 = 0.5
AND G04	0.8	1 (yes)	CF4 = 0.8
AND G05	0.5	1 (yes)	CF5 = 0.5
AND G06	0.4	1 (yes)	CF6 = 0.4
AND G07	0.4	1 (yes)	CF7 = 0.4
AND G08	0.4	1 (yes)	CF8 = 0.4
AND G09	0.6	1 (yes)	CF9 = 0.6
AND G010	0.6	1 (yes)	CF10 = 0.6
AND A01	0.4	1 (yes)	CF11 = 0.4
AND A02	0.7	1 (yes)	CF12 = 0.7
AND K01	0.7	1 (yes)	CF13 = 0.7
AND K02	0.7	1 (yes)	CF14 = 0.7

TABLE III
CALCULATION OF CF(H,E) FOR ALL SYMPTOMS ANSWERED 'YES' TO THE PNEUMONIA RULE

Symptom's Code	CF Expert	CF User	CF(h,e)
IF G04	0.8	1 (yes)	CF1 = 0.8
AND G05	0.5	1 (yes)	CF2 = 0.5
AND K02	0.7	1 (yes)	CF3 = 0.7

TABLE IV
CALCULATION OF CF(H,E) FOR ALL SYMPTOMS ANSWERED 'YES' IN THE RULE OF TYPHOID FEVER

Symptom's Code	CF Expert	CF User	CF(h,e)
IF G01	0.7	1 (yes)	CF1 = 0.7
AND G03	0.5	1 (yes)	CF2 = 0.5
AND G06	0.4	1 (yes)	CF3 = 0.4
AND G07	0.4	1 (yes)	CF4 = 0.4
AND G08	0.4	1 (yes)	CF5 = 0.4

The value of CF(h,e) in the table rules above is entered in the calculation formula number (3). This calculation will later produce a combination CF value close to 1 (because everything is answered 'yes'). The following is the combined CF calculation for the rules of COVID-19, Pneumonia, and Typhoid Fever.

TABLE V
COMBINATION CF CALCULATION FOR ALL SYMPTOMS ANSWERED 'YES' TO THE COVID-19 RULES

CF Combination (CFK)	CF1+CF2(1 – CF1)	Result
CFK1 [CF1, CF2]	0.7 + 0.7 (1-0.7)	0.91
CFK2 [CFK1, CF3]	0.91 + 0.5 (1-0.91)	0.9145
CFK3 [CFK2, CF4]	0.9145 + 0.8 (1-0.9145)	0.9829
CFK4 [CFK3, CF5]	0.9829+ 0.5 (1-0.9829)	0.99145
CFK5 [CFK4, CF6]	0.99145+ 0.4 (1-0.99145)	0.99487
CFK6 [CFK5, CF7]	0.99487 + 0.4 (1-0.99487)	0.996922
CFK7 [CFK6, CF8]	0.996922+ 0.4 (1-0.996922)	0.998153
CFK8 [CFK7, CF9]	0.998153 + 0.7 (1-0.998153)	0.999445
CFK9 [CFK8, CF10]	0.999445 + 0.7 (1-0.999445)	0.999833
CFK10 [CFK9, CF11]	0.999833 + 0.4 (1-0.999833)	0.999900
CFK11 [CFK10, CF12]	0.999900+ 0.7 (1-0.999900)	0.999970
CFK12 [CFK11, CF13]	0.999970+ 0.6 (1-0.999970)	0.999988
CFK13 [CFK12, CF14]	0.999988+ 0.6 (1-0.999988)	0.999995
Final Result (x100)		99.9995%

TABLE VI
COMBINATION CF CALCULATION FOR ALL SYMPTOMS ANSWERED 'YES' TO THE PNEUMONIA RULE

CF Combination (CFK)	CF1+CF2(1 – CF1)	Result
CFK1 [CF1, CF2]	0.8 + 0.5 (1-0.8)	0.9
CFK2 [CFK1, CF3]	0.9 + 0.7 (1-0.9)	0.97
Final Result (x100)		97%

TABLE VII
COMBINATION CF CALCULATION FOR ALL SYMPTOMS ANSWERED 'YES' TO THE PNEUMONIA RULE

CF Combination (CFK)	CF1+CF2(1 – CF1)	Result
CFK1 [CF1, CF2]	0.7 + 0.5 (1-0.7)	0.85
CFK2 [CFK1, CF3]	0.85 + 0.4 (1-0.85)	0.91
CFK3 [CFK2, CF4]	0.91 + 0.4 (1-0.91)	0.946
CFK4 [CFK3, CF5]	0.946 + 0.4 (1-0.946)	0.9676
Final Result (x100)		96.76%

After getting the final results from the combined CF of each disease rule, the next step is to sort from the highest to the lowest value. Then, the application will show which one is the highest value at the end of Siska page. There will be a massage to warn the user about keeping their health safe.

TABLE VIII
THE ORDER OF THE COMBINED CF FINAL RESULTS FROM HIGH TO LOW

Order	Rules	Combined CF (%)
1	COVID-19	99.99952130944%
2	Pneumonia	97%
3	Typhoid Fever	96.76%

From the results of these calculations, it can be seen that the Combination CF value of COVID-19 is the first possibility experienced by the user, the expert system will diagnose the user with COVID-19 as shown in Figure 3, then the expert system will suggest to check health by undergoing laboratory tests for ensure the results of the expert system diagnosis. The second possibility experienced by the user is Pneumonia and the third possibility experienced by the user is Typhoid Fever.

Figure 3. Diagnose result if user answered 'yes' to all questions

B. User answers all questions with 'no'

We can detect a person's initial exposure to COVID-19 by checking body temperature as is done and found at the entrance of public places. Therefore, the first question (G01) on the

expert system is regarding the user's temperature, which can be seen in Figure 4 (left).

Figure 4. Question G01 about temperature and Pneumonia (G04)

If the user answers the question with 'no', it can be ascertained that he is not involved with COVID-19 or Typhoid Fever. However, it cannot be separated from the disease associated with COVID-19, namely Pneumonia. Therefore, the expert system will lead to the first question regarding Pneumonia, namely on G04, which can be seen in Figure 4 (right). After that, users can continue to answer questions if they answer 'yes' or experience symptoms like G04.

If the user answers 'no' to the G04 symptom, it is certain that the user is free from COVID-19 symptoms or is said to be healthy as shown in Figure 5. From the overall answer 'no' will make the value of CF(e) become 0, then for the value of CF(h,e) will follow to 0 which makes the value of CF Combination [CF1, CF2] to 0 as well.

Figure 5. The results of the expert system diagnosis if all answer 'no'

C. *Maps menu for COVID-19 positive detections*

In the system block diagram (Figure 1), it can be seen that to access the application, a Wi-Fi connection is required. This is because the maps menu requires the same Wi-Fi network to be able to detect the presence of users diagnosed as positive for COVID-19. The user's location will be saved in the database at the last login. So, the presence or location of the user will change when the user logs back into the application. Maps will count the number of positives within a range of WiFi standards (802.11 a/b/g).

To be able to detect COVID-19 positive on the menu maps, the user must have a history of diagnosis stating COVID-19. So, we will create 3 accounts (2 users and 1 admin) as test material. For example, we used admin and user 1 to be diagnosed positive COVID-19 person by expert system.

Then, user 1's account will be outside the detection range of the admin maps menu but within the range of user 2 and in the same Wi-Fi network, namely in the AI Building of the Malang State Polytechnic. Figure 7 shows the detection of 1 positive (yellow) on the user 2 map menu.

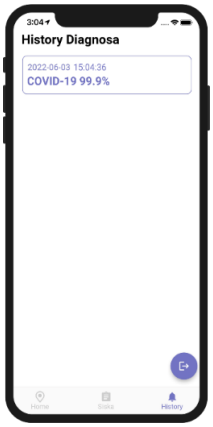

Figure 6. Positive COVID-19 diagnose history by user 1

Figure 7. The display of the user maps menu if user 1 beyond the reach of the admin

Then, user account 1 will be within the detection range of the admin maps menu and one Wi-Fi network, namely at the kos room which is located next to the boarding house, then on the maps menu 2 positives (yellow) will be detected in Figure 8.

The use of short-term memory in building a system, especially an expert system, has proven to be simple, efficient,

fast, and easy because it does not require database storage to store existing symptoms [14].

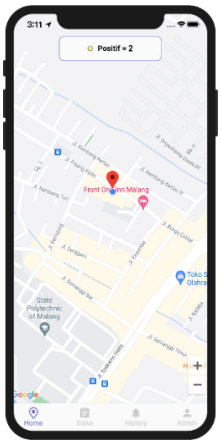

Figure 8. The display of the admin maps menu

D. Application evaluation

To test the quality level of an application, it takes respondents who will try and judge. The evaluation that will be taken is the suitability of the diagnosis results to the symptoms suffered by the respondent, the accessibility of the application, and the respondent's satisfaction with the application. The evaluation of the application has been assessed by 14 respondents consisting of 3 employees, 2 freelancers, 7 students, 1 medical student who is on clinical year, and 1 nurse. From this assessment, the following results were obtained.

At the time of testing the application on respondents, there were 2 out of 14 respondents who felt that they did not match the results of the diagnosis as shown in Figure 9. This is because when the respondent tries to answer 'yes' to the symptoms that lead to Typhoid Fever, the expert system issues a diagnosis in the form of COVID-19 instead of Typhoid Fever.

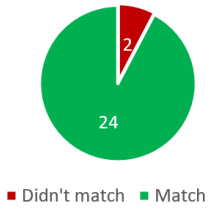

Figure 9. Graph of the suitability of the diagnosis

Assessment of the accessibility of the application for the easy-to-use category, as many as 1 person disagreed, 2 people disagreed, 5 people agreed, and 7 people strongly agreed.

Then on the assessment of the accessibility of the application for the easy-to-understand category, as many as 1 person stated that they did not agree, 3 people stated that they did not agree, 4 people stated that they agreed, and 4 people stated that they strongly agreed.

Furthermore, in the assessment of the accessibility of the application for the informative category, as many as 2 people stated that they did not agree, 1 person stated that they did not agree, 7 people stated that they agreed, and 4 people stated that they strongly agreed.

In the last accessibility assessment, namely the interactive category, 1 person disagreed, 1 person disagreed, 7 people agreed, and 5 people strongly agreed. The summary of accessibility evaluation can be seen in figure 10.

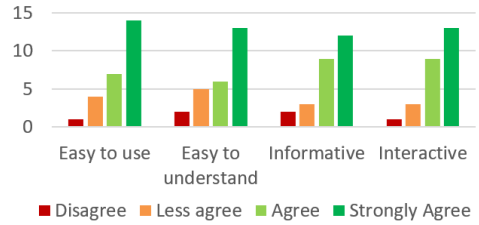

Figure 10. Accessibility rating chart

Assessment of satisfaction in the use and service of the application can be shown in Figure 11.

The graph shows that as many as 1 person stated that they were not satisfied, 2 people stated that they were not satisfied, 6 people stated that they agreed, and 5 people stated that they strongly agreed. The chart of satisfaction can be seen in Figure 11.

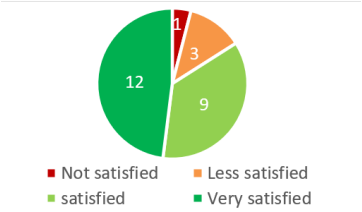

Figure 11. Graph of user satisfaction with the application

Software testing is done by using black-box testing, which is a technique of analyzing the results of application design by going through test data and checking every function that exists in the software whether it is running well or not [15][16].

IV. CONCLUSION

From the research and design of the COVID-19 diagnosis expert system that has been carried out, it can be concluded that the research resulted in an application of an expert system for diagnosing COVID-19 using the iOS-based Certainty Factor method to answer the user's uncertainty about the symptoms of COVID-19 they are experiencing, so that the expert system can diagnose the status of patients with COVID-19, Pneumonia, Typhoid Fever depends on the answers to the symptom questions. Based on the calculated CF(h,e) and CF combinations on symptoms and rules, the expert system produced a confidence level of 99.9995% for the COVID-19 rule, 97% for the Pneumonia rule, and 96.76% for the Typhoid Fever rule. The trust value is in accordance with what is displayed on the iOS application.

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