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Expert System for COVID-19 Detection Using Forward Chaining and Certainty Factor Method Based on Android Mobile

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ABSTRACT

The Coronavirus began to enter Indonesia on March 2, 2020, starting from an Indonesian citizen who had physical contact with a Japanese citizen at a dance club event in Jakarta. The Covid-19 cases continued to spread rapidly, with 2,178,272 positive cases recorded on June 30, 2021. The advancement of artificial intelligence technology in the medical field has brought about an expert system that can replace experts in early Covid-19 detection. This is due to the high cost of conducting rapid tests, swab tests, and PCR (polymerase chain reaction) tests, as well as the lack of experts in handling Covid-19 cases. An expert system using the forward chaining and certainty factor methods based on Android can help individuals detect whether they are positive or negative for Covid-19 in the early stages, independently.

Keyword: Covid-19, Expert System, Forward Chaining, Certainty Factor

I. INTRODUCTION

Early 2020, the world was shaken by the spread of a new variant of virus, namely the Coronavirus (SARS-CoV-2), which caused the disease known as Coronavirus Disease 19 (COVID-19). It is known that the virus originated from Wuhan, China, and was discovered at the end of December 2019 [1]. According to WHO data on March 1, 2020, the number of people infected with COVID-19 was 87,137 cases, with 79,968 cases reported from China (spread across 34 regions, including Hong Kong, Macau, and Taipei). The total number of deaths was 2,977 cases, with a Case Fatality Rate (CFR) of 3.4%, of which 2,873 were reported from China. Countries outside of China, such as the Philippines, Japan, South Korea, France, Iran, and Italy, confirmed a total of 6,009 cases with 86 deaths [2]. Based on data until March 2, 2020, the mortality rate worldwide was 2.3%, while in Wuhan city it was 4.9% and in Hubei Province it was 3.1%. In other provinces in China, the mortality rate was 0.16% [3]. Around 80% of people infected with COVID-19 recover without the need for special treatment. People who are 50 years old or older and those who have underlying medical conditions such as high blood pressure, heart and lung disorders, diabetes, or cancer are more susceptible to infection [4]. The spread of COVID-19 can be transmitted through direct physical contact, such as through touching, or through the air when sneezing and coughing [5].

The lack of information and many people not following health protocols, such as not wearing masks, sneezing carelessly, not avoiding crowds, and not maintaining distance [6]. This has caused a rapid increase in COVID-19 cases in Indonesia [7]. To address this, a computerized system is needed so that the public can learn about the symptoms and causes of the disease.

Expert system is a computerized application used to solve problems as a professional/expert would think [10]. The expert referred to here is someone who has special expertise to solve problems that cannot be solved by ordinary people. For example, a doctor is an expert who is able to diagnose the disease suffered by a patient and provide solutions for the disease [11].

In expert systems, there are several methods that can be used for detection, namely the forward chaining method and certainty factor (CF) [12]. Forward chaining is one of the methods in an expert system that is capable of providing a diagnosis based on existing facts [13]. The facts consist of information about the patient's condition, such as the symptoms experienced [14]. Each fact will undergo hypothesis testing to generate a conclusion/decision in the form of a diagnosis result and its treatment process [15]. Next, the displayed symptoms will be calculated using the certainty factor method [16].

The Certainty Factor (CF) is a theory proposed by Shortliffe and Buchanan in 1975 to accommodate the uncertainty in expert thinking (such as a doctor) who often analyzes information with expressions such as "might," "likely," and "almost certain.".

The certainty factor method is used to accommodate the level of expertise in facing a problem. This method is applied when dealing with problems where the answer is uncertain. This uncertainty can be in the form of probabilities [17].

II. RESEARCH METHOD

A. Type of Research

This research belongs to the type of quantitative research. This is because the research uses data in the form of raw numbers or percentages of a variable.

B. Data Collection

1. Literature Study

This research uses secondary data, which is collected through several books, journals, the internet, and other reading sources.

2. Questionnaire

To collect data, this research uses a data collection technique in the form of a questionnaire or survey conducted by providing a set of questions about symptoms related to Covid-19.

3. Interview

An interview was conducted with Mrs. Wilda Andayani, Amd. Keb, who is one of the nurses at Estomihi Hospital in Medan. From the interview, information related to Covid-19 was obtained, and the nurse provided weights/expert values for each symptom.

C. Analysis System

In this stage, analysis is carried out on the reasoning that will be used in the inference engine. This research uses 2 reasoning techniques, namely forward chaining and certainty factor:

1. Forward Chaining Method

Forward chaining is executed by collecting the available facts to draw a conclusion. Each fact will result in a conclusion in the form of a detection result.

2. Certainty Factor Method

In this method, the expert system will present a form of prediction of various Covid symptoms, which is a result of data detected by the expert system that can be executed or the percentage of the disease process used in determining a form of detection result. Here is the calculation of the value using the certainty factor method as follows:

$$CF(H,e) = CF(E,e) * CF(H,E) \quad (1)$$

CF (H, e) is hypothesis that is influenced by evidence, CF (E,e) is User value, CF (H, E) is Expert value, H is Hypothesis and E is Evidence (event or fact).

If there are more than one symptom, the next calculation uses the combination formula. Here is the combination formula (2)

$$CF_{combine} = CF_{old} + CF_{gejala} * [1 - CF_{old}] \quad (2)$$

To obtain a value for each data, CF (rule) value obtained from the interpretation of terms by the expert is needed, which is converted into a certain CF value.

Table 1 The Rule Of CF

Uncertain Term	The expert's CF value
Definitely not	0
Unknown	0.2
Maybe	0.4
Probably	0.6
Almost Certainly	0.8
Definitely	1

D. Design System

The system design in this study uses system planning, which is illustrated by Unified Modeling Language (UML) modeling, including use case diagrams and activity diagrams.

1. Use case diagram

Based on Figure 1, it explains how users detect diseases based on the symptoms they feel, resulting in the detection results. The process of detecting Covid-19 begins with the user opening the application. Then the system will display the home menu, which contains data about Covid and some information about the application. Then the user selects the detection form, the detection form contains a list of symptoms. Next, the user selects the options of the symptoms felt and the system will automatically process based on the selected answers. After the user has answered all the questions, the system will automatically provide the results of the detection process. The result obtained from the detection process is only two, which are positive or negative for Covid-19 and accompanied by the level of accuracy.

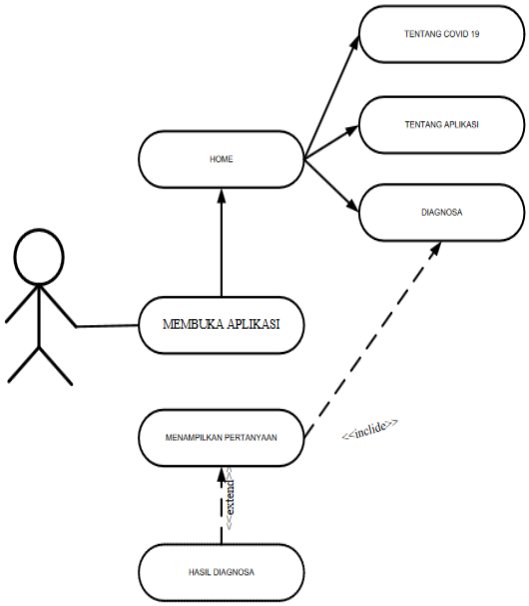

Figure 1 Use case diagram application

2. Activity Diagram

In the figure 2, it shows the flow of the expert system that will run once the user starts running the application. The system starts when the user selects the options of perceived symptoms, the user is required to answer all

questions in the application. Then the system will automatically provide an inference from the detection results. All questions containing Covid-19 symptoms, user activity history, and body condition have been calculated with various MYCIN rule combination rules in the certainty factor method. The result (inference) of the expert system is generated by forward chaining in the form of conclusions and recommendations.

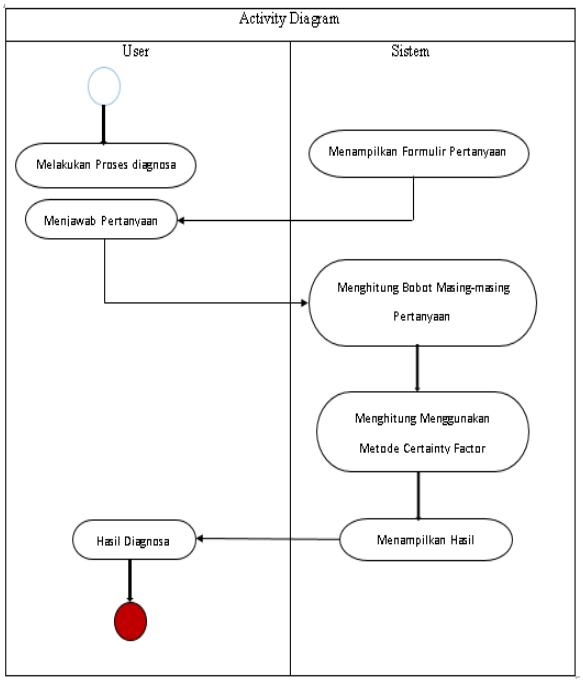

Figure 2 Activity Diagram

E. Implementation of the System

The implementation of the system in this study uses the C programming language by inputting the rules of the inference engine using forward chaining reasoning and applying the certainty factor method.

F. Testing Technique

The testing technique used in this study is Black Box Testing. Black Box Testing is used to test specific functions of the designed software, and to determine whether the input and output functions of the software are in accordance with the required specifications.

III. RESULT AND DISCUSSION

A. Certainty Factor Analysis

Here is a list of symptoms and their codes in the system. These symptoms are sourced from several studies.

The certainty factor method in the questionnaire filling session is given several options, each of which has several weights as follows:

1. Yes : 1.0
2. Almost Certain : 0.8
3. Likely : 0.6
4. Maybe : 0.4
5. Dont Know : 0.2
6. No : 0

Table 2. Covid 19 Symptom data

Symptom Code	Symptom List	Expert CF
G01	Sore Throat	0,4
G02	Fever	0,6
G03	Cough	0,4
G04	Sneezing	0,6
G05	Runny Nose	0,2
G06	Shortness of Breath	0,6
G07	Lost Of Taste	0,4
G08	Lost Of Smell	0,6
G09	Red Eyes	0,4
G10	Muscle Pain	0,4
G11	Chills	0,2
G12	Loss Of Appetite	0,8
G13	Weakness	0,4

The following are the detection results obtained in one of the Covid-19 patients at Estomihi Hospital in Medan.

.

IF Sore Throat AND Fever AND Cough AND Runny Nose AND Loss Of Taste AND Red Eyes AND Muscle Pain AND Chills AND Weakness THEN Positif Covid 19

After obtaining the expert's and user's values, the next step is to calculate the expert's CF value with the user's CF value using the following equation:

Table 3. Calculate of Covid19

Symptom Code	Symptom	CF (Expert)		CF (User)	Evidence	CF (H,E)
G01	Sore Throat	0,4	*	1	Yes	0,4
G02	Fever	0,4	*	1	Yes	0,4
G03	Cought	0,6	*	0,8	Almost Certaint	0,48
G05	Runny Nose	0,2	*	1	Yes	0,2
G07	Loss Of Taste	0,6	*	0,8	Almost Certaint	0,48
G09	Red Eyes	0,4	*	1	Yes	0,4
G10	Muscle Pain	0,4	*	0.8	Almost Certaint	0,32
G11	Chills	0,2	*	1	Yes	0,2
G13	Weakness	0,4	*	1	Yes	0,4

Next step is to calculate the combination of the multiplication result of each symptom. The calculation of the combination can only be done if there is more than one symptom. The following is the calculation of the combination result obtained.

$$CF_{combine}\,CF(H,e)_{1,2} = CF(H,e)_1 + CF(H,e)_2 * (1 - CF(H,e)_1)$$

$$= 0{,}4 + 0{,}4 * (1 - 0{,}4)$$

$= 0{,}4 + 0{,}24$

$= 0{,}64$ CFold

$CF_{combine}\ CF\ (H,e)_{old,3} = CF\ (H,e)_{old} + CF\ (H,e)_3 * (1 - CF\ (H,e)_{old})$

$= 0{,}64 + 0{,}48 * (1 - 0{,}64)$

$= 0{,}64 + 0{,}172$

$= 0{,}81$ CFold

$CF_{combine}\ CF\ (H,e)_{old2,4} = CF\ (H,e)_{old2} + CF\ (H,e)_4 * (1 - CF\ (H,E)_{old2})$

$= 0{,}81 + 0{,}2 * (1 - 0{,}81)$

$= 0{,}84$ CFold

$CF_{combine}\ CF\ (H,e)_{old3,5} = CF\ (H,e)_{old3} + CF\ (H,e)_5 * (1 - CF\ (H,E)_{old3})$

$= 0{,}84 + 0{,}48 * (1 - 0{,}84)$

$= 0{,}84 + 0{,}07$

$= 0.91$CFold

$CF_{combine}\ CF\ (H,e)_{old4,6} = CF\ (H,e)_{old4} + CF\ (H,e)_6 * (1 - CF\ (H,E)_{old6})$

$= 0{,}91 + 0{,}4 * (1 - 0{,}91)$

$= 0{,}91 + 0{,}03$

$= 0{,}94$CFold

$CF_{combine}\ CF\ (H,e)_{old5,7} = CF\ (H,e)_{old5} + CF\ (H,e)_7 * (1 - CF\ (H,E)_{old5})$

$= 0{,}94 + 0{,}32\ (1 - 0{,}94)$

$= 0{,}94 + 0{,}01$

$= 0.95$CFold

$CF_{combine}\ CF\ (H,e)_{old6,8} = CF\ (H,e)_{old6} + CF\ (H,e)_8 * (1 - CF\ (H,E)_{old6})$

$= 0{,}95 + 0{,}2\ (1 - 0{,}95)$

$= 0{,}95 + 0{,}01$

$= 0{,}96$CFold

$CF_{combine}\ CF\ (H,e)_{old7,9} = CF\ (H,e)_{old7} + CF\ (H,e)_9 * (1 - CF\ (H,E)_{old7})$

$= 0{,}96 + 0{,}4\ (1 - 0{,}96)$

$= 0{,}97$

The CFCOMBINE value is = CFCOMBINE * 100% => 0.97 * 100% = 97%. Therefore, the conclusion is that the confidence level of the system in calculating the certainty factor for Covid-19 is 97%

B. Implementation System

1. Login Form

The login form of the application consists of a name and email field. Users can fill in their name and email to proceed to the next page. Here is the display of the login form:

Figure 4. Login Form

2. Visitor Home

The display of the home menu consists of the test menu, information menu, and exit menu. Here is the display of the visitor's home menu:

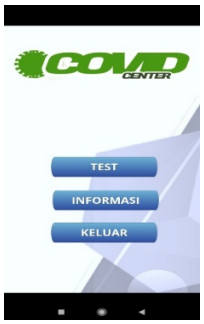

Figure 5. Visitor's Home

3. Testing

On this menu, 13 symptoms will be displayed, and the user is required to select several symptoms that match the user's condition. The following are some questions about Covid-19 symptoms:

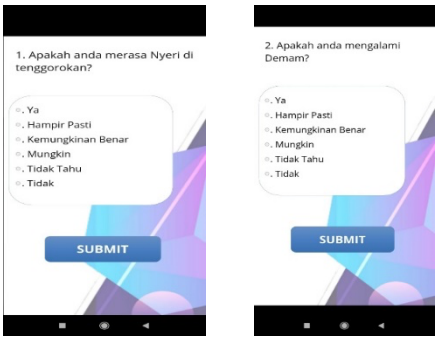

Figure 6 Menu Test Covid19

After selecting the appropriate symptoms, the user can click the submit button to display the diagnosis result. The display of the detection result can be seen in the image below:

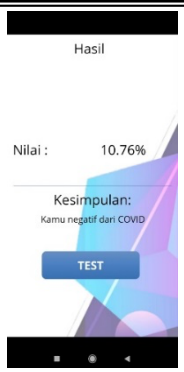

Figure 7. Detection Result

4. Information

This display contains information about Covid19 and how to prevent being infected by the virus.

Figure 8. Information Menu

5. Explanation

This display contains an explanation about what is Covid-19, whether Covid-19 is contagious, the causes of Covid-19, the symptoms experienced by Covid-19 patients, and how to prevent Covid-19.

IV. CONCLUSION

Based on the analysis, system design, and evaluation conducted, the Covid19 expert system using the forward chaining and certainty factor methods on Android mobile platform works well. The experimental evaluation of the system for detecting Covid19 showed an accuracy of 97%. The designed system can help the community to detect Covid without having to go to the doctor or hospital.

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