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Expert System for Diagnosing Covid-19 Disease Using Method Forward Chaining

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Abstract – December 2019 was the beginning of cases that hit the Wuhan area, increasing cases of Covid-19 in China every day and increasing from January to February 2020. Initially reports came from the Hubei area and surrounding provinces, and the reports that came increased to the provinces around China, there were 86 other cases reported from various parts of the country, including Indonesia. Indonesia's first Covid-19 disease reportedly entered on March 2, 2020, there were two cases. The latest information is published on the official WHO website (World Health Organization) it was recorded that from January 3, 2020 to March 18, 2022 in Indonesia, there were 5,948,610 people who were recorded as positive for Covid-19 and 153,411 people were confirmed to have died. Diagnosing Covid-19 is the job of experts or specialists who have experience and knowledge in this field. An alternative that can help people who are not experts in diagnosing Covid-19 is an expert system. The forward chaining method was chosen because it is a forward tracking technique that is sorted according to the number of facts and ends with a conclusion. Forward Chaining is a method inference engine where this method compares facts and statements and will start from the left first (IF). Where, reasoning will start from the facts and then test the validation of the hypothesis (THEN). This research was conducted to make it easier for non-experts to diagnose Covid-19 with this expert system, and to be able to provide solutions after a successful diagnosis.

Keywords - Covid-19, Diagnosis, Expert Systems, Methode Certainty Factor, Method Forward Chaining.

I. INTRODUCTION

December 2019 was the beginning of cases that hit the Wuhan area, increasing cases of Covid-19 in China every day and increasing from January to February 2020. Initially reports came from the Hubei area and surrounding provinces, and the reports that came increased to other provinces around China, there were 86 cases others were reported from various countries such as Taiwan, India, South Korea, the Philippines, Australia, Canada, Finland, Nepal, Sri Lanka, Thailand, Vietnam, Malaysia, Cambodia, Japan, Singapore, Saudi Arabia, France and Germany [1]. Indonesia's first Covid-19 disease reportedly entered on March 2, 2020, there were two cases. The latest information published on the official WHO website (World Health Organization) it was recorded that from January 3, 2020 to March 18, 2022 in Indonesia, there were 5,948,610 people who were recorded as positive for Covid-19 and 153,411 people were confirmed to have died [2].

Diagnosing Covid-19 is the job of an expert who has knowledge and experience. The limitations of someone who is not an expert in diagnosing Covid-19 disease are often wrong, due to lack of knowledge and experience. An expert system can be an alternative that can help people diagnose the Covid-19 disease. Expert systems can be defined as applications of artificial intelligence where the system contains knowledge from one or more related experts in a particular field [3]. Many methods can be used to build expert systems, such as Forward Chaining, Certainty Factor, Backward Chaining, Depth First Search, and others [4]. The expert system built is widely used to help everyday life. One of them is to diagnose a disease [5]. Forward Chaining is a method inference engine where this method compares facts and statements and will start from the left first (IF) [6]. This expert system can identify user problems related to dementia disease. Its use is similar to query tracing using the forward-chaining method used to draw conclusions based on conclusions drawn from answers to various questions asked by users [7]. The forward chaining method performs processing starting from a set of symptoms, which are then carried out in inference to produce a diagnosis The data used for research consists of 30 symptoms and 10 eye diseases [8]. Where, reasoning will start from the facts first in testing the validation of the hypothesis (THEN) [9].

This method is a form of strategy to get results or certainty that starts from looking for facts in an expert system. This process is carried out by providing data in a working memory, then this process is repeated until a goal or result is found [10]. Concepts that have been tested for truth are based on research results related to the author's research topic using the method Forward Chaining for early diagnosis of a disease is the result of research conducted by Aggy Pramana Gusman, Dian Maulida and Eva Rianti in 2019 entitled “Expert System for Diagnosis of Ovarian Cyst Disease using the Forward Chaining Method” [11]. Similar research also uses Methods Forward Chaining carried out by Ranti Eka Putri, Kriscillia Molly Morita and Yanti Yusman in their journal entitled “Application of the MethodForward Chaining in Expert Systems to Know Someone's Personality” [12].

This research was conducted to make it easier for non-experts to diagnose Covid-19 using an expert system method Forward Chaining, and can provide solutions after successful diagnosis. Apart from that, even though Covid-19 will be declared endemic, it is hoped that this method can help in diagnosing whether the disease is included in the Covid-19 category or not, so that in the future this method can be used sustainably. Praya Health Center is one

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of the health centers that has received several cases related to Covid-19, where there are local residents who have tested positive for Covid-19. To get real data on handling this case, the author conducted research at the Praya health center, as well as experts who had handled Covid-19 cases before.

II. RESEARCH METHODOLOGY

2.1 Research Stages

This data was obtained from literature studies, medical databases, and collaboration with health institutions, namely the Praya Health Centre and experts who have handled COVID-19 cases before. Researchers then integrated the data into the system to model the reasoning process with the forward chaining method. The stages of this expert system research are made in a flow chart which is arranged clearly and in stages so that it can be used as a reference in conducting research so that it can be made according to previously planned research objectives. The stages of the research flow are as follows:

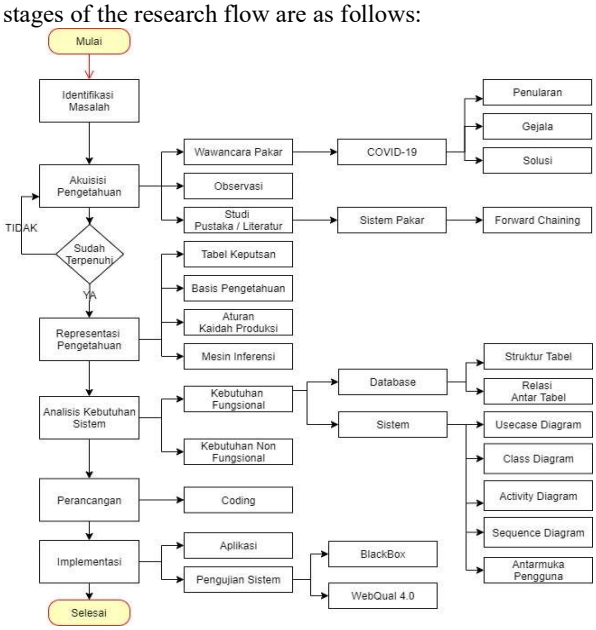

Fig 1. Research Flow Stages

The following is an explanation of the research flow stages that have been designed by the author:

a. The author identifies the problem of the Covid-19 disease which was the reason for the pandemic even though it has recently been declared endemic. It is hoped that in the future this method can be used sustainably.
b. At the knowledge representation stages the author carries out the process of modeling the data that has been collected at the problem identification stage so that it is easy to understand.
c. System Requirements Analysis is a stage where the author analyzes what the system needs, such as functional requirements and non-functional requirements.
d. Design is the stage where the writer carries out coding to build the system.
e. Implementation is the stage where the application system is tested.

2.2 Method Forward Chaining

Forward Chaining is a method used to find conclusions, starting from previously existing facts, then comparing all the facts using sections IF from rules or rules IF-THEN. If in partIF If there are appropriate facts, then the rule will be executed. And if a rule is executed, then the facts in the section THEN will be added in database. Each comparison will begin with a rule. Each Rule can only be executed once. The comparison process will stop if it is no longer thererule which can be compared [8]. While MethodBackward Chaining is a control of a thought to achieve a goal or goal [13]. Hence the method Forward Chaining applied to this expert system [14].

2.3 Method Certainty Factor

Shortliffe Buchanan introduced the method certainty factor (CF) which can be used to calculate the level of confidence for a decision maker. An expert often explains information with assumptions such as the words “possible”, “most likely” and “almost certain”. There are two factors that cause uncertainty in a question presented by the system to experts, namely something that is not certain rule/rules from experts and something that is not certain, namely the answer given user [15].

2.4 Test Method Black-Box

The method commonly used in testing a software without observing the details of software This is a testing method Black-Box. Method Black-Box just analyzes the value output based on the value input of each function available on software which will be tested. The program code used does not need to be analyzed. Testing process Black-Box is the process of program analysis by input data on each form-to find out how far along the program software can run according to needs [16].

III. RESULTS AND DISCUSSION

3.1 Knowledge Representation

The knowledge representation model in this expert system uses production rules where the writing form is if-then. There are 3 diagnostic results, namely Negative, Reactive, Positive for Covid-19, each diagnosis will be accompanied by a solution. Each of these solutions ensures that expert system users get the right direction to respond to their diagnosis results, supporting more effective management of individual and community health. The diagnostic table will explain the diagnostic results in this system:

Table 1. Diagnosis

No.	Diagnostic Code	Diagnosis Name
1.	D001	Negative
2.	D002	Reactive
3.	D003	Positive

a. Decision Table

Decision tables are a way to document knowledge gained from experts. The following is the decision table for this research [3]:

Table 2. Decision Table

Code	Symptom Name	Diagnosis		
		D001	D002	D003

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G001	Cough	✓		
G002	Have a cold	✓		
G003	Fever	✓		
G004	Fatigue	✓		
G005	Headache	✓		
G006	Loss of Appetite	✓		
G007	Loss of Sense of Smell (Anosmia)		✓	
G008	Loss of Sense of Taste (Ageusia)		✓	
G009	Sore throat		✓	
G010	Coughs and colds accompanied by shortness of breath		✓	
G011	Asthma		✓	
G012	Red Eyes/Irritation		✓	
G013	Diarrhea		✓	
G014	Muscle ache		✓	
G015	Pulmonary Hypertension			✓
G016	Diabetes Mellitus			✓
G017	Heart failure (Decompression of the Heart)			✓
G018	Pneumonia (Pneumonia)			✓
G019	Pain in the Chest			✓
G020	Hard to breath			✓

b. Knowledge Base

Knowledge base is a particular form of information or knowledge that is used for knowledge management. Knowledge base functions in several processes, namely collecting, organizing and rediscovering knowledge. The method used for calculation operations in this system is method Certainly Factor where the knowledge base used therein is Diagnosis, Symptoms, MB (Measure of increased belief) and MD (Measure of increased disbelief), based on the Term Interpretation value in the method Certainty Factor [17]:

Table 3. Mark Interpretation of terms

No	Information	Mark
1	Very confident	1
2	Confident	0.8
3	Sure enough	0.6
4	A little sure	0.4
5	Not sure	0.2
6	Very Unsure	0

The following table shows the knowledge base obtained by the author after carrying out the expert interview process:

Table 4. System Knowledge Base

Code	Symptom Name	MB	MD
G001	Cough	0.6	0.2
G002	Have a cold	0.6	0.2
G003	Fever	0.6	0.4
G004	Fatigue (Fatigue)	0.6	0.4
G005	Headache	0.6	0.4
G006	Loss of Appetite (Anorexia)	0.6	0.2
G007	Loss of Smell (Anosmia)	0.8	0.2
G008	Loss of Taste (Ageusia)	0.8	0.2
G009	Sore throat	0.6	0.4
G010	Coughs and colds accompanied by shortness of breath	0.8	0.2
G011	Asthma	0.8	0.2
G012	Red Eyes/Irritation	0.4	0.2
G013	Diarrhea	0.4	0.2
G014	Muscle ache	0.4	0.2
G015	Pulmonary Hypertension	1	0.2
G016	Diabetes Mellitus	0.6	0.2
G017	Heart Failure (Decompression Cordis)	1	0.2
G018	Lung Inflammation (Pneumonia)	1	0.2
G019	Pain in the Chest	0.8	0.2
G020	Hard to breath	0.8	0.2

The next stage after the MB and MD weight values are obtained is to accumulate the CF values for each symptom using calculation formula (1), the results of calculation (1) can be seen in table 5 [18]:

CF [H,E] = MB[H,E] - MD[H,E] (Basic). (1)

Table 5. The value given by the expert is according to the diagnosis

Code	Symptom Name	Diagnosis		
		D001	D002	D003
G001	Cough	0.4		
G002	Have a cold	0.4		
G003	Fever	0.2		
G004	Fatigue	0.2		
G005	Headache	0.2		
G006	Loss of Appetite (Anorexia)	0.4		
G007	Loss of Sense of Smell (Anosmia)		0.6	
G008	Loss of Sense of Taste (Ageusia)		0.6	
G009	Sore throat		0.2	
G010	Coughs and colds accompanied by shortness of breath		0.6	
G011	Asthma		0.6	
G012	Red Eyes/Irritation		0.2	
G013	Diarrhea		0.2	
G014	Muscle ache		0.2	
G015	Pulmonary Hypertension			0.8
G016	Diabetes Mellitus			0.4
G017	Heart failure (Decompression of the Heart)			0.8
G018	Pneumonia (Pneumonia)			0.8
G019	Pain in the Chest			0.6
G020	Hard to breath			0.6

3.2 Process Method Forward Chaining

Method Forward Chaining applied as a rule or inference engine to the system from a decision table that has been made in ordering the symptoms experienced by the user and providing the right solution according to the results provided by the user. Then the author makes production rules in preparing symptoms according to table 5 as follows:

Table 6. Production Rules

Code	Rules
R001	**If** Cough **And** Have a cold **And** Fever**And** Fatigue **And** Headache **And** Loss of Appetite **For** Negative
R002	**If** Loss of Sense of Smell (Anosmia) **And** Loss of Sense of Taste (Ageusia) **And** Sore throat **And** Cough **And** Colds accompanied by shortness of breath **And** Asthma **And** Red Eyes/Irritation **And** Diarrhea **And** Muscle ache**For** Reactive
R003	**If** Pulmonary Hypertension**And** Diabetes Mellitus **And** Heart Failure (Decompression Cordis) **And** Lung Inflammation (Pneumonia) **And** Pain in the Chest **And** Hard to breath **For** Positive

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Next it will be simplified in a chart arranged according to table 6 To make it easier for the author to understand in creating the system, the following is a flowchart for implementing the method Forward Chaining:

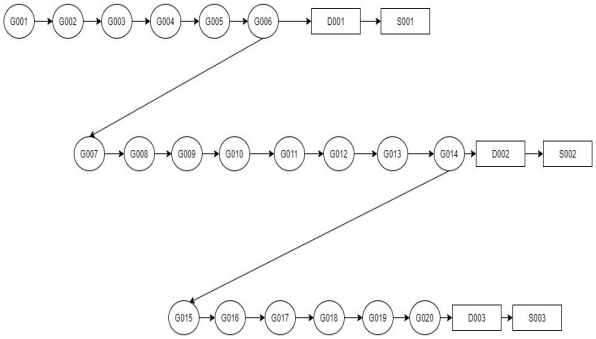

Fig 2. Application of the Forward Chaining Method

The symptoms that will be displayed to the user will be displayed in the form of questions that will be answered according to the symptoms experienced by the user themselves, as follows:

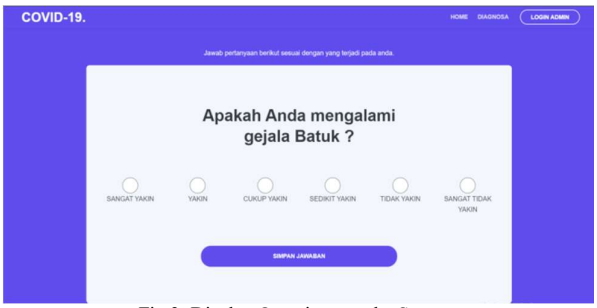

Fig 3. Display Questions on the System

3.3 Calculation Process

The accumulation process used in the system is a calculation method Certainty Factor, where in this case answers are needed from users regarding the symptoms they are experiencing as well as expert knowledge who have dealt with Covid-19. Users will answer according to the values interpretation of terms (can be seen at table 3) found in the Method Certainty Factor which is the decision determining value of the method [15]. The following is an example of a user answer with values interpretation of terms in Methods Certainty Factor regarding the symptoms experienced:

Table 7. Example User Answers

Code	Symptom Name	User Answers
G001	Cough	0.8
G002	Have a cold	0.8
G003	Fever	1
G004	Fatigue	1
G005	Headache	1
G006	Loss of Appetite	0.6
G007	Loss of Sense of Smell (Anosmia)	0
G008	Loss of Sense of Taste (Ageusia)	0
G009	Sore throat	0.2
G010	Coughs and colds accompanied by shortness of breath	0
G011	Asthma	0
G012	Red Eyes/Irritation	0.2
G013	Diarrhea	0
G014	Muscle ache	0
G015	Pulmonary Hypertension	0
G016	Diabetes Mellitus	0
G017	Heart failure (Decompression of the heart)	0
G018	Pneumonia (Pneumonia)	0
G019	Pain in the Chest	0.2
G020	Hard to breath	0

The user's answers will then be accumulated with a value determined by the expert as described in table 5. The formula used to accumulate expert data values with user answers [17]:

$$CF[H,E] = CF[H] * CF[E] \text{ (Single)} \quad (2)$$

Information:

CF[E] / E = Evidence is a fact supporting the patient's hypothesis.
CF[H] / H = Hypothesis results sought/obtained from facts obtained through experts.
CF[H,E] = The results of the Certainty Factor are obtained from the expert hypothesis (H) and the patient hypothesis (E).

The following table shows the calculation process based on each alternative diagnosis result according to the answers given by the user and expert knowledge.

Table 8. Negative Diagnosis Single CF Calculation

Code	Symptom Name	Calculation CF[H] * CF[E]	Result (H)= CF[H,E]
G001	Cough	0.4 * 0.8	H1= 0.32
G002	Have a cold	0.4 * 0.8	H2= 0.32
G003	Fever	0.2 * 1	H3=0.2
G004	Fatigue	0.2 * 1	H4 = 0.2
G005	Headache	0.2 * 1	H5= 0.2
G006	Loss of Appetite	0.4 * 0.6	H6= 0.24

Table 9. Reactive Diagnostic Single CF Calculation

Code	Symptom Name	Calculation CF[H] * CF[E]	Result (H)= CF[H,E]
G007	Loss of Sense of Smell (Anosmia)	0.6 * 0	H1= 0
G008	Loss of Sense of Taste (Ageusia)	0.6 * 0	H2=0
G009	Sore throat	0.2 * 0.2	H3 = 0.04
G010	Coughs and colds accompanied by shortness of breath	0.6 * 0	H4 = 0
G011	Asthma	0.6 * 0	H5=0
G012	Red Eyes/Irritation	0.2 * 0.2	H6= 0.04
G013	Diarrhea	0.2 * 0	H7= 0
G014	Muscle ache	0.2 * 0	H8=0

Table 10. Calculation of CF Single Positive Diagnosis

Code	Symptom Name	Calculation CF[H] * CF[E]	Result (H)= CF[H,E]
G015	Pulmonary Hypertension	0.8 * 0	H1= 0
G016	Diabetes Mellitus	0.4 * 0	H2=0
G017	Heart failure	0.8 * 0	H3=0
G018	Pneumonia (Pneumonia)	0.8 * 0	H4 = 0
G019	Pain in the Chest	0.6 * 0.2	H5= 0.12
G020	Hard to breath	0.6 * 0	H6= 0

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After getting the accumulated results from user answers with expert values, the accumulated results will be combined with the formula [17]:

CF[H,E] = CF[x] + CF[y] (1 - CF[x]) (Combination) (3)

Information:

CF[H,E]	=	The results of the certainty factor obtained from experts (H) and patients (E).
CF[x]	=	Initial CF or CF from previous calculations
CF[y]	=	Second CF or next CF

The following is the calculation process based on each alternative diagnosis:

Table 11. Negative Diagnosis Combination CF Calculation

Combination CF	Calculation CF[x] + CF[y] (1 - CF[x])	Results Combination
H1 and H2	0.32 + 0.32 (1 – 0.32)	CFc1 = 0.537
CFc1 and H3	0.537 + 0.2 (1 – 0.537)	CFc2 = 0.629
CFc2 and H4	0.629 + 0.2 (1 – 0.629)	CFc3 = 0.703
CFc3 and H5	0.703 + 0.2 (1 – 0.703)	CFc4 = 0.762
CFc4 and H6	0.762 + 0.24 (1 – 0.762)	CFc5 = 0. 819
RESULTS		**0.82 (82%)**

Table 12. Reactive Diagnostic Combination CF Calculation

Combination CF	Calculation CF[x] + CF[y] (1 - CF[x])	Results Combination
H1 and H2	0 + 0 (1 – 0)	CFc1 = 0
CFc1 and H3	0 + 0.04 (1 – 0)	CFc2 = 0.04
CFc2 and H4	0.04 + 0 (1 – 0.04)	CFc3 = 0.04
CFc3 and H5	0.04 + 0 (1 – 0.04)	CFc4 = 0.04
CFc4 and H6	0.04 + 0.04 (1 – 0.04)	CFc5 = 0.07
CFc5 and H7	0.07 + 0 (1 – 0.07)	CFc6 = 0.07
CFc6 and H8	0.07 + 0 (1 – 0.07)	CFc7 = 0.07
RESULTS		**0.07 (7%)**

Table 13. CF Calculation of Positive Diagnostic Combinations

Combination CF	Calculation CF[x] + CF[y] (1 - CF[x])	Results Combination
H1 and H2	0 + 0 (1 – 0)	CFc1 = 0
CFc1 and H3	0 + 0 (1 – 0)	CFc2 = 0
CFc2 and H4	0 + 0 (1 – 0)	CFc3 = 0
CFc3 and H5	0 + 0.12 (1 – 0)	CFc4 = 0.12
CFc4 and H6	0.12 + 0 (1 – 0.12)	CFc4 = 0.12
RESULTS		**0.12 (12%)**

So, based on the answers from users the resulting diagnosis results are:

1. Negative diagnosis result = 82%
2. Reactive diagnosis results = 7%
3. Positive diagnosis result = 12%

Then the user's diagnosis results are Negative.

3.4 System Calculation Results

Fig 4. System Calculation Results

Figure 4 is the diagnosis result of the user's answer which has been adapted to the user case example in table 7. Comparison of manual diagnostic calculation results with system diagnostic results is as follows:

Table 14. Comparison of Manual Calculation Results with the System

Diagnosis	The calculation results	
	Manual Calculation	System Calculation
Negative	82%	82%
Reactive	7%	8%
Positive	12%	12%
Diagnostic Results	**Negative**	**Negative**

IV. CONCLUSION

This expert system is a system that can channel expertise in early diagnosis of COVID-19. Flow methodForward Chaining which is implemented can run well on the system, and provide correct results according to the calculation methodCertainty Factor as a reference for certainty. Comparison of manual calculation results with system results has the same direction. Based on the results of comparing laboratory tests with the results of comparison point-2, it shows the same decision direction, with a percentage accuracy of 70%. Based on test results on users, user satisfaction is at a percentage of 60-84%, indicating that users are satisfied with using the system. There are also several suggestions that can be used as a reference for the next steps in developing this expert system, namely being able to create an Android-based system so that it can be used on any device, being able to add a feature for downloading diagnostic results, and being able to implement the method used by the author with different cases.

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