The Expert System of Children's Digestive Tract Diseases Diagnostic using Combination of Forward Chaining and Certainty Factor Methods

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***Abstract*—Disease diagnosis usually is done by a doctor; however, the number of doctors is still far from ideal condition. Expert systems are becoming a solution and have been widely used for disease diagnosis. This paper proposes an expert system using forward chaining and certainty factor to diagnose symptoms of digestive tract diseases in children. The expert system is designed to be web-based so that it can be used by more people. Method of forward chaining is used for the search direction, while the method of certainty factor is used to provide confidence in a result. Testing is done by comparing the results of system diagnosis with expert diagnosis. The results showed that this system has an accuracy of 100% with confidence value of 80,5%. The results suggest that it can be used to diagnose digestive tract diseases in children.**

Keywords—Expert System; Digestive Disease; Forward Chaining; Certainty Factor

I. INTRODUCTION

Digestive tract diseases are all diseases that occur in the digestive tract, such as colon cancer, typus and so on. According to WHO, colon cancer is the 6th leading cause of death in the world. The cause of the disease can be viruses, bacteria, weak immune system, malnutrition, and others.

Early diagnosis of the symptoms of the disease is one of the aggravating factors so that the patients are considered late when knowing the disease. The importance of early diagnosis is inversely proportional to the availability of experts in the disease. The expert system is a system that adopts a person's expertise (in this research is a doctor) in solving a problem. Expert systems have been widely used to solve problems in various fields, such as health, scheduling, controlling, design, and so on. Based on this, the expert system is the solution proposed in this research.

Many methods are used in expert systems, such as forward chaining, backward chaining, certainty factor, and others. Research on expert systems using forward chaining method has been done by researchers such as: [1] using forward chaining for analysis of Micro Mobile MPLS, [2] using forward chaining for mobile multicast architecture with management support, [3] using forward chaining For Detecting Mental Disorder, [4] using forward chaining for Personal Financial Planner, [5] using forward chaining for Diagnosing Human Vitamin Deficiency, [6] using forward chaining for Diagnosing General Symptoms of Disease. Similarly, expert system research using certainty factor methods has been widely used, such as [7] using certainty factor for Dynamic Estimation in ClassNiers, [8] using certainty factor for Surgery Intelligence, [9] using certainty factor for diagnosis of the disease Treatment with prayer by the verse of the newspaper, [10] using certainty factors for Early Diagnosis Of Meningitis Disease, [11] uses two-layer with machine learning to early diagnosis of dementia.

Nevertheless, previous research has not yet combined the two methods where one is for conclusion search and the other counts the belief of the conclusion. In fact, the forward chaining method has an advantage in tracking the rule while the certainty factor method gives a percentage of certainty result. Based on the advantages of each method, in this study, author propose the expert system of children's digestive tract diseases diagnosed using a combination of forward chaining and certainty factor methods.

The rest of this paper is organized as follows. Section 2 introduces the methodology for the expert system construction. Section 3 proposes the model and the experimental results of the research of expert systems. Finally, section 4 draws the conclusion.

II. RESEARCH METHOD

The research method is illustrated in Fig. 1. The first step is to determine the problem, in this case, it is a digestive tract disease in children. The second step is to conduct literature studies on symptoms of digestive diseases, and to interview experts in their field. The third step is to create a model that describes the functional model. It is a use case diagram that describes user and system interaction. The fourth step is to develop an expert system prototype by applying a combination of forward chaining and certainty factor methods. The prototype development follows a linear sequence process model in software engineering disciplines with an object- oriented approach. The fifth step is testing the system to test the accuracy of the system to the human expert.

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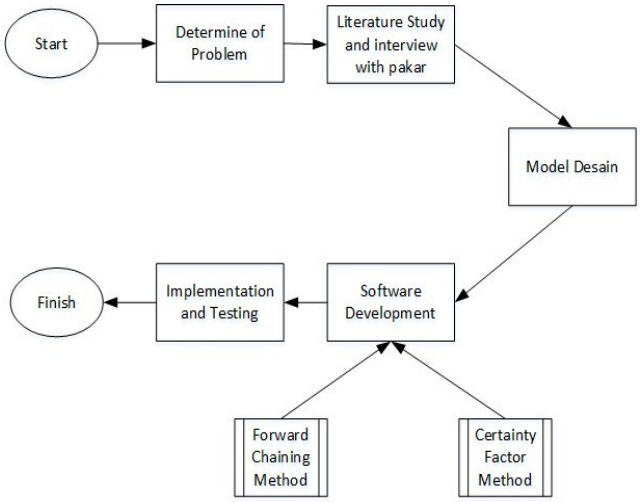

Fig. 1. Research step.

The forward chaining method is often referred to as search- driven data [3]. In this method, the search for conclusions or goals is based on facts obtained. These facts form a chain or path to the conclusion. Diagram of forward chaining method can be seen in Fig. 2. Based on Fig. 2, it appears that to achieve the objective / conclusion K, the facts that must be true are A, D, and H. Algorithmically, tracing the facts to achieve goals / conclusions can be written using the if..then rules. Example rule if ... then:

- If A then D
- If A and C then F
- If D then H
- If H then K

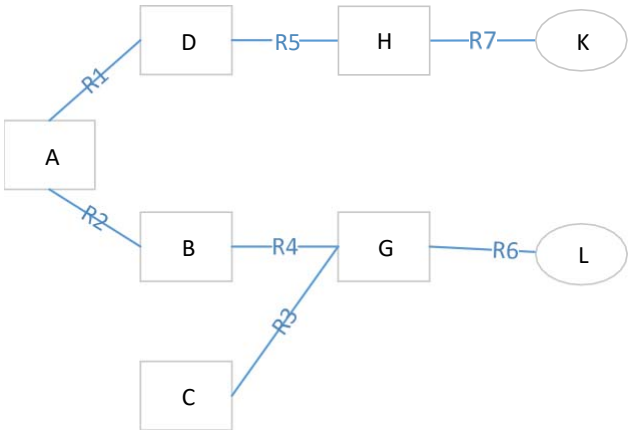

Fig. 2. Forward Chaining Diagram.

Certainty factor determines the presentation of certainty to a fact with the formula:

$$CF[h,e] = MB[h,e] - MD[h,e] \quad (1)$$

where :

CF[h,e] = Certainty factor

MB[h,e] = measure of belief, A presentation of trust

MD[h,e] = measure of disbelief, Presentation of distrust or degree of confidence in the hypothesis (h), if given or a level of confidence in the hypothesis (h), if given evidence (e). MB value between 0 and 1evidence (e). MD value between 0 and 1.

As for some certainty factor combination to certain premise:

1. Certainty factor with one premise.

$$CF[h,e] = CF[e] * CF[rule]$$

$$= CF[user] * CF[expert] \quad (2)$$

2. Certainty factor with more than one premise.

$$CF[A \wedge B] = Min(CF[a],CF[b]) * CF[rule] \quad (3)$$

$$CF[A \vee B] = Max(CF[a],CF[b]) * CF[rule] \quad (4)$$

3. Certainty factor with similar conclusions.

$$CFCombined\ [CF_1, CF_2] = CF_1 + CF_2 * (1 - CF_1) \quad (5)$$

This research uses a combination of two methods, namely forward chaining and certainty factor in finding conclusions. Forward chaining method is used to find conclusions while certainty factor method is used to determine conclusion confidence. In general, the rules of diagnosis of children's digestive tract diseases can be seen in formula 2.

$$IF\ E_1\ [AND / OR]\ E_2\ [AND / OR] \ldots E_n\ THEN\ H\ (CF = CF_i) \quad (6)$$

where:

$E_1 \ldots E_n$: Evidence

H : Conclusion

CF : Confidence level (Certainty Factor) hypothesis H due to the facts E_1 to E_n.

III. Research Results

From Fig. 3, it can be seen that the system has two users namely administrators and patients. Administrators can perform data processing symptoms, disease data, update rules and create diagnostic reports. In the meantime, the patients interact with the system to diagnose the disease and get a report of the diagnosis. For security, the system uses user authentication that can change data and rules through login. By logging in, a highly qualified admin can perform data processing and rules, so that the data and rule will be edited, added, or deleted correctly as needed. Thus the system will not give the diagnosis a fool.

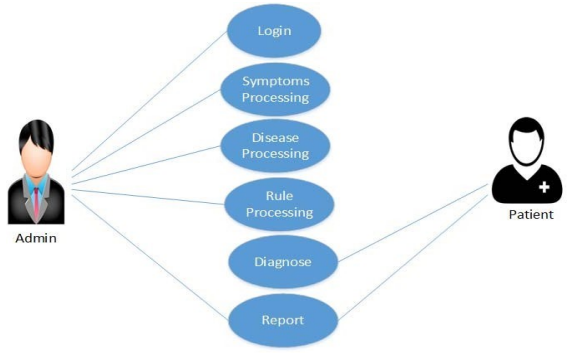

Fig. 3. Expert system model of digestive disease in children.

In this research, children's digestive tract disease has ten types of diseases with various causes. This expert system uses the rule as its cores. Here are the rules of the expert system of digestive tract diseases in children:

***Rule* 1 : IF** nausea and vomiting or one of them **AND** fever **AND** defecate more than 3 times a day **THEN** Acute diarrhea

***Rule* 2 : IF** nausea and vomiting or one of them **AND** fever **AND** defecate more than 5 times a day, **THEN** Mild dehydration diarrhea

***Rule* 3 : IF** nausea and vomiting or one of them **AND** fever **AND** sunken eyes **AND** vomiting often **AND** diarrhea somewhat often **AND** light thirst **THEN** Moderate dehydration diarrhea

***Rule* 4 : IF** nausea and vomiting or one of them **AND** fever **AND** sunken eyes **AND** vomiting very often **AND** diarrhea very often AND heavy thirst **AND** decreased skin immunity **THEN** Severe dehydration diarrhea

***Rule* 5 : IF** nausea and vomiting or one of them **AND** mild fever **AND** diarrhea **AND** total abdominal pain **AND** shivering **THEN** Peritonitis

***Rule* 6 : IF** nausea and vomiting or one of them **AND** mild fever **AND** diarrhea **AND** cramps **THEN** Intoxication

***Rule* 7 : IF** nausea and vomiting or one of them **AND** Mild fever **AND** Lower right abdominal pain **AND** bowel sounds increase **THEN** Intestinal inflammation

***Rule* 8 : IF** nausea and vomiting or one of them **AND** difficult to defecate **AND** pale **AND** high fever **AND** navel out pus **AND** heart beating too fast / too slow **THEN** Duodenal sepsis

***Rule* 9 : IF** nausea and vomiting or one of them **AND** difficult to defecate **AND** hard to eat **AND** weight loss **AND** swelling of the stomach **AND** feces rounded **THEN** Hisprung

***Rule* 10 : IF** nausea and vomiting or one of them **AND** difficult to defecate **AND** Abdominal pain disappear and arise after one **AND** greenish vomit **THEN** Obstructive ileus

Example calculation of certainty factor: if known symptoms lead to rule 1, such as:

Rule 1: IF nausea and vomiting or one of them AND fever AND defecate more than 3 times a day THEN Acute diarrhea. The CF value of the expert for the above symptoms is :

1. CFexpert1 (nausea and vomiting or one of them) = 0.7
2. CFexpert2 (fever) = 0.6
3. CFexpert3 (defecate more than 3 times a day) = 0.7

Suppose the user selects the answer as follows:

1. CFuser1 = Very confident = 1
2. CFuser2 = Confident = 0.8
3. CFuser3 = Sure enough = 0.6

Then the manual counting process for each symptom is as follows :

1. CFsymptoms1 = CFuser1*CFexpert1
   = 1 * 0.7
   = 0.7
2. CFsymptoms2 = CFuser2*CFexpert2
   = 0.8 * 0.6
   = 0.48
3. CF symptoms3 = CFuser3*CFexpert3
   = 0.6 * 0.7
   = 0.42

Since there are more than one symptom, then to determine the next disease, CF uses the following equation:

1. CFcombine(CF symptoms1,CF symptoms2)

   = CF symptoms1+CF symptoms2*(1-CF symptoms1)

   = 0.7 + 0.48 * (1-0.7)

   CFold1 = 0.844
2. CFcombine2(CFold1,CF symptoms3)

   = CFold1 + CF symptoms3 * (1-CFold1)

   = 0.844 + 0.42 * (1-0.844)

   CFold3 = 0.90952

The last CFold is the CF value of Acute Diarrhea disease, based on the above calculation, the CF value of Acute Diarrhea is 0.90952. Next, calculate the percentage of confidence against the disease by using the equation:

Percentage = CF disease * 100

= 0.90952 * 100

= 90.952 %

The experiment was conducted on sample data in the form of medical records of patients who had been diagnosed by experts.

The system accuracy test is done by comparing the diagnostic results of the system with the results of the expert diagnosis. Test results can be seen in Table I and Table II. Table I shows the accuracy of diagnosis of visible symptoms. While Table II shows the test system to patients with symptoms.

Table I shows that the diagnostic results by the system and the results of diagnosis by the experts are the same. Likewise, the value of confidence given by the system is not much different from the results of manual calculations. This means the system runs according to rules and formulas that have been set.

Table II describes the results of system testing in diagnosing patients. Patient data are taken from his medical record. The amount of patient data is 10 patients. In detail the patient data and the diagnosis and diagnosis confidence value can be seen in Table II.

TABLE I. TESTING SYSTEM WITH MANUAL CALCULATION

No	Symptoms	CF (Expert)	CF (User)	CF (Manual)	CF (System)	Disease (expert)	Disease (System)
1.	1. Nausea and vomiting or one of them 2. Fever 3. Defecate more than 3 times a day	0.7 0.6 0.7	0.7 0.6 0.7	0.80048	0.80 or 80%	Acute diarrhea	Acute diarrhea
2.	1. Nausea and vomiting or one of them 2. Mild fever 3. Lower right abdominal pain 4. Bowel sounds increase	0.7 0.8 0.8 0.7	0.6 0.4 0.8 0.8	0.94006144	0.95 or 95%	Intoxication	Intoxication
3.	1. Nausea and vomiting or one of them 2. Abdominal pain 3. Stomach pain	0.7 0.6 0.6	0.6 0.8 0.6	0.806976	0.81 or 81%	Gastritis	Gastritis
4.	1. Nausea and vomiting or one of them 2. Fever up and down 3. Less comfortable to follow 4. Muscles feel sore and sore 5. Sluggish 6. Complete headache	0.7 0.6 0.7 0.7 0.8 0.6	0.6 1 0.6 0.2 0.4 0.8	0.9590406144	0.96 or 96%	Tyfus	Tyfus
5.	1. Nausea and vomiting or one of them 2. Decreased appetite 3. Skin yellowing 4. The urine is dark 5. The eyes are yellow	0.7 0.6 0.9 0.7 0.8	0.2 0.2 1 0.4 0.6	0.97166368	0.97 or 97%	Hepatitis C	HepatitisC

TABLE II. TEST RESULTS OF SAMPLE DATA

No	Initial Patient	Expert diagnosis	System diagnosis	
		Diseases	*Disease*	*CF*
1	AF	Acute diarrhea	Acute diarrhea	**85%**
2	FD	Intoxication	Intoxication	**75%**
3	DN	Gastritis	Gastritis	**79%**
4	DR	Gastritis	Gastritis	**84%**
5	YR	Acute diarrhea	Acute diarrhea	**72%**
6	HD	Gerd	Gerd	**81%**
7	RW	Inflammation of the Colon	Inflammation of the Colon	**90%**
8	TA	Gastritis	Gastritis	**85%**
9	NK	Acute diarrhea	Acute diarrhea	**78%**
10	SF	Constipation	Constipation	**76%**

Based on Table II, it can be seen that the diagnosis produced by this expert system is the same as the diagnosis that is presented by the expert. To give confidence to the diagnosis, the system adds a certainty factor value to the diagnosis. Based on the average calculation as in formula 7 it is seen that the average certainty factor value is 80.5%. Based on Likert scale, the value is in good category.

The average value of system accuracy is:

$$\frac{85 + 75 + 79 + 84 + 72 + 81 + 90 + 85 + 78 + 76}{10} = 80{,}5\% \quad (7)$$

Thus this system gives confidence to the users that the diagnosis is 80.5% correct. This system is web-based, so it can be accessed by anyone and anywhere. Thus it can be very helpful for residents who are far from health services.

IV. CONCLUSION

Digestive tract disease in children is a dangerous disease and can cause death. Therefore, there needs to be early detection of symptoms. In this study the author proposes expert system using a combination of forward chaining and certainty factor to diagnose symptoms of digestive tract diseases, where forward chaining is to determine the direction of tracking and certainty factor is to calculate the value of the diagnostic confidence. Based on the experiments conducted, the diagnosis results have 100% accuracy compared with the diagnosis produced by the expert with the degree of confidence generated in good category (80.5%). This system is designed web-based so that it can be accessed anywhere and anytime. With these advantages the system is very useful for residents who are in areas far from health services so that the negative impact of digestive tract disease can be minimized.

In future researceh, author will study to implement machine learning technique to increase confidence value.

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