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Development of An Expert System for The Diagnosis of Kidney Disease Using the Certainty Factor Method

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ABSTRACT

Kidney disease is a prevalent health issue affecting millions of people globally. Early and accurate diagnosis of kidney diseases can help in the timely and effective management of the condition. Expert systems, such as those using the Certainty Factor (CF) method, can provide doctors with valuable assistance in diagnosing kidney diseases more efficiently and accurately. This study aims to develop a kidney disease diagnosis expert system using the CF method. The developed system consists of data collection, data storage, and data processing components, with the CF method used to calculate diagnostic confidence levels and decision-making based on predetermined rules. The knowledge acquisition process was carried out by interviewing three nephrologists to obtain rules for diagnosing kidney diseases. The expert system's evaluation is conducted by comparing the system's diagnostic accuracy with a specialist doctors. The results show that the developed expert system has an accuracy rate of 85.7% in diagnosing kidney diseases. The system also has a user-friendly interface, which allows doctors to input symptoms and obtain a diagnosis quickly and accurately. The developed system has several advantages over traditional diagnosis methods. It can diagnose multiple kidney diseases simultaneously and provide a differential diagnosis, allowing doctors to choose the most appropriate treatment plan for their patients. The system also has the potential to reduce diagnostic errors and improve patient outcomes.

Keywords: C++, Certainty Factor, expert system, Kidney

INTRODUCTION

The kidney is a vital organ shaped like a red bean, weighs 150 grams, and consists of 2 parts, the left and right. (Julisawaty et al., 2020) The kidney is the most significant human organ. Although humans can survive with a single kidney, it has many functions. Its functions include controlling blood volume and composition, maintaining acid-base balance, controlling blood pressure, removing foreign substances, controlling the concentration of electrolytes in the extracellular fluid, and many more. (Fathushahib & Marselia, 2018)

Every year, the number of deaths caused by kidney disease is increasing because many people still do not know about the early symptoms of kidney disease, and health facilities, especially the kidneys in Indonesia, are still very limited. Kidney disease will readily occur if the immune System begins to decrease and decrease, allowing any bacteria or microorganisms to enter the body. (Fanny et al., 2017) Kidney disease can be handled in consultation with a specialist in internal medicine who will diagnose the symptoms the patient feels quickly and precisely. (Hendry et al., 2021) So the health sector also requires computer technology. One of the methods used to diagnose kidney disease is an expert system.

An expert system is a computer program that uses human knowledge to make a decision, such as a decision made by an expert or an expert. (Ponnusamy et al., 2021) The purpose of an expert system is not to replace the position of an expert or an expert but only to disseminate the knowledge and experience of experts. (Fathushahib & Marselia, 2018) One of the methods used in developing expert systems for disease diagnosis is the Certainty Factor method. The certainty factor (CF) is a clinical parameter value MYCIN gives to indicate the level of trust. Two kinds of certain factors are used: certainty factors filled in by experts and rules and certainty factors provided by users. (Setiawan, 2017) This method calculates the probability of a diagnosis based on the symptoms found in the patient. This research developed an expert system for diagnosing kidney disease using the Certainty Factor method.

The certainty Factor method is a method of reasoning in expert systems that can overcome uncertainty in disease diagnosis. (Dhar et al., 2021) This method calculates the level of certainty or confidence in a statement or diagnosis so that the expert system can provide a more accurate and precise diagnosis. (Selleh & Saudi, 2019) The formula for the Certainty factor is as follows:

$$CF(H|E) = MB(H|E) - MD(H|E)$$

This study attempted to develop an expert system for diagnosing kidney disease with high accuracy using the Certainty Factor method. The developed expert System can assist doctors in making more accurate and faster decisions in treating patients with kidney disease. (Zhuang et al., 2021) By using an accurate expert system, it is hoped that the diagnosis of kidney disease can be carried out more efficiently and treatment can be given promptly to prevent more severe complications. (Esperto et al., 2021)

METHOD

Using an expert system begins with building the system, which requires gathering knowledge from

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kidney experts, compiling a knowledge base, and assigning a CF value for each symptom. The output of this process is the accuracy of the diagnosis and the solution for the type of kidney disease that has been identified. There are six types of kidney disease: acute kidney failure, chronic kidney failure, kidney stones, kidney infection, kidney cancer, and kidney failure. Table 1 lists the disease classification codes.

Table I. Types of Disease

Code	The Type of Disease
P001	Acute Kidney Failure
P002	Chronic Renal Failure
P003	Kidney stones
P004	Kidney Infection
P005	Kidney Cancer
P006	Kidney failure

Many symptoms can appear in disease, so each type of disease has its own rules. Types of kidney disease are limited to the common ones. Table 2 presents the variable-based coding for each symptom.

Table II. Symptoms of Disease

Code	Symptoms of Disease
G001	Severe back pain (colic)
G002	Pain when urinating
G003	Fever
G004	Pee a little
G005	Red urine/blood
G006	Frequent urination
G007	Loss of appetite
G008	Tired and weak
G009	Trouble sleeping
G010	Muscles twitch and spasm
G011	Swelling in the leg area
G012	Itchiness occurs
G013	Pain When Urinating
G014	Urine where pink, red, or brown
G015	Nausea and vomiting
G016	Frequent urination
G017	Back, hip, or groin pain
G018	Abdominal pain
G019	Pus or blood in the urine
G020	The body feels exhausted without any reason
G021	Pain on the side that does not go away
G022	Presence of Blood in the Urine
G023	High blood pressure
G024	Blood in Urine
G025	Weakness and difficulty sleeping
G026	Headache
G027	Out of breath

Not all heart disease has the same symptoms, and different types of heart disease have different symptoms that significantly impact the type of disease. This symptom is given the most weight so that if chosen, at least one has a significant impact, it will impact the accuracy of the diagnosis of the type of disease. Figure 1 provides a more thorough overview of each disease symptom.

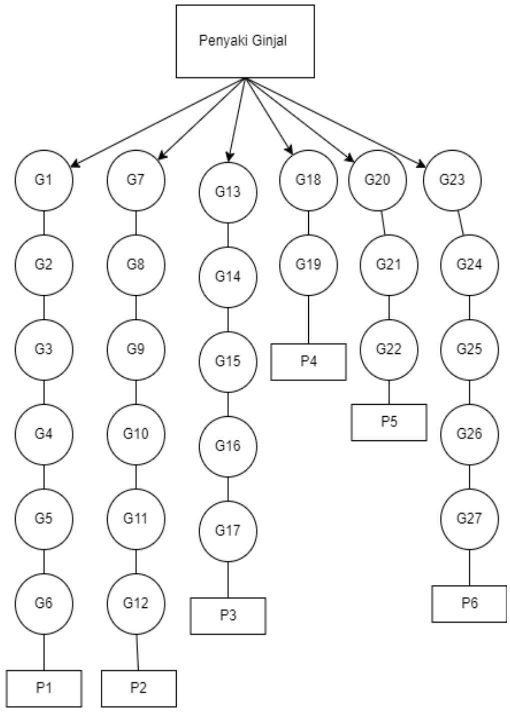

Figure 1 Decision Tree

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The production rules in this system design are expressed in code format as IF [assume] THEN [conclusion]. The basic design of this expert system is built based on symptoms and conclusions that affect the type of kidney disease, so the statement pattern is IF (symptoms) THEN (type of disease symptoms). A rule can have several symptoms in this expert system. Each linked symptom is combined using the logical operator (AND). Table III will explain the statement pattern.

Table III. Rule CF

No	*Rule*
1	IF G001 AND G002 AND G003 AND G004 AND G005 AND G006 THEN P001
2	IF G007 AND G008 AND G009 AND G010 AND G011 AND G012 THEN P002
3	IF G013 AND G014 AND G015 AND G016 AND G017 THEN P003
4	IF G018 AND G019 THEN P004
5	IF G020 AND G021 AND G022 THEN P005
6	IF G023 AND G024 AND G025 AND G026 AND G027 THEN P001

When using the certainty factor approach, it is essential to balance the type of disease, the user's level of confidence in the symptoms of the disease, and the symptoms of the disease. From 0 to 1, symptoms and confidence levels are weighted. Table IV lists the disease weights.

Table IV. Disease Weight

No.	Certainty Term	Weight
1.	Not sure	0
2.	Likely No	0.2
3.	Do not know	0.5
4.	Possible Yes	0.8
5.	Certain	1

Calculating the weight of symptoms based on their influence on the type of disease can determine each symptom in each condition. The level of confidence the system user has in each displayed symptom is determined by the currently available weights, influencing the type of diagnosed condition selected. Table V provides more specific symptom weights for each condition.

Table V. Symptom CF Value

No	Symptom Code	The type of disease	CF Question	No	Symptom Code	The type of disease	CF Question
	K(	Acute Kidney Failure	0.6	15.	KG15	Kidney stones	0,3
	K(	Acute Kidney Failure	0,6	16.	KG16	Kidney stones	0,3

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	K	Acute Kidney Failure	0,2	17.	KG17	Kidney stones	0.7
	K	Acute Kidney Failure	0,4	18.	KG18	Kidney Infection	0,7
	K	Acute Kidney Failure	0,5	19.	KG19	Kidney Infection	0,8
	K	Acute Kidney Failure	0,6	20.	KG20	Kidney Cancer	0,5
	K	Chronic Renal Failure	0,2	21.	KG21	Kidney Cancer	0,5
	K	Chronic Renal Failure	0,5	22.	KG22	Kidney Cancer	0,8
	K	Chronic Renal Failure	0,2	23.	KG23	Kidney failure	0,5
	K	Chronic Renal Failure	0,7	24.	KG24	Kidney failure	0,8
	K	Chronic Renal Failure	0,7	25.	KG25	Kidney failure	0,3
	K	Chronic Renal Failure	0,3	26.	KG26	Kidney failure	0,2
	K	Kidney stones	0,7	27.	KG27	Kidney failure	0,4
	K	Kidney stones	0,8				

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The certainty factor method in expert systems is analyzed using the certainty factor method. The certainty factor method is a method that measures the certainty value given by an expert on a rule and overcomes difficulties in determining the symptoms of kidney disease. The following is the formula for the Certainty Factor method to assume the certainty of an expert on data.

$$CF(H|E) = MB(H|E) - MD(H|E)$$

Information:

1. CF[H, E]: cf of evidence-influenced hypotheses.
2. MB(H,E) : hypothesis confidence per evidence.
3. MD(H,E) : great distrust hypothesis per evidence.
4. H: The resulting hypothesis or conclusion (between 0 and 1).
5. E: Evidence or events or facts (symptoms)

The next calculation is a combination of two or more rules with additional evidence but in the same hypothesis:

1. Rule 1
   $CF(H, E1) = CF1 = C(E1) \times CF(Rule1)$
2. Rule 2
   $CF(H, E2) = CF2 = C(E2) \times CF(Rule2)$
3. Combination CF
   $(CF1, CF2) = CF1 + CF2(1 - CF1)$

RESULTS and DISCUSSION

In this preparation stage, there are three test data from patients who have suffered from various diseases, including all the symptoms felt by the patient, which will be used in testing the expert system with the certainty factor method to determine whether the accuracy of the expert system matches the type of disease the patient is suffering from. The testing phase will begin after the test data preparation stage is complete. By entering the patient's symptoms as system input variables, the system will be considered to have expert users. The testing phase results must be validated to ensure the accuracy of the system's predictions. The output of the expert system is the type of disease diagnosed, and the accuracy percentage will be compared with the actual type of disease experienced by the user at the results validation stage. In Table VI, three test data have been described.

Table VI. Test Results of Kidney Disease Patients

Patient 1	Fever	Hard to breathe
	Frequent urination	
	Urine is red	Weakness and difficulty sleeping
	Trouble sleeping	Low back pain

Patient 2	Pain when urinating	Trouble sleeping
	Frequent urination	Urine is pink, red or brown
Patient 3	The body feels tired and weak without any reason	Pain on the side that does not go away
	Lost appetite	There is blood in the urine
	fever	Headache

Based on the results of previous tests, the system will adjust by paying attention to the symptoms entered by the user, the confidence level they choose, and the weight of the impact of these symptoms on various types of kidney disease. At the calculation stage, the user's CF value initializes the user's confidence level. The user's CF value calculates the symptom weight in the first phase. User-selected symptoms and the level of assurance on symptoms listed in Table VI describe the calculated results for each patient.

Table VI. Results of Calculation of CF Values in Patients

Patient	**The Type of Disease**	**Combination CF Results**	**Accuracy (CFx100%)**
Patient 1	Acute Kidney Failure	0.954944	**95.4944%**
	Chronic Renal Failure	0.583898	58.3898%
	Kidney stones	0.904643	90.4643%
	Kidney Infection	0.40	40%
	Kidney Cancer	0.46	46%
	Kidney failure	0.544	54.4%
Patient 2	Acute Kidney Failure	0.91168	91.168%
	Chronic Renal Failure	0.3808	38.08%
	Kidney stones	0.958	**95.8%**
	Kidney Infection	0	0%
	Kidney Cancer	0.244	24.4%
	Kidney failure	0.412	41.2%
Patient 3	Acute Kidney Failure	0.296	29.6%

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	Chronic Renal Failure	0.52	52%
	Kidney stones	0.79876	79.876%
	Kidney Infection	0.484	48.4%
	Kidney Cancer	0.95	**95%**
	Kidney failure	0.86464	86.464%

The results of the accuracy of each type of disease for the three patients are expressed in percentages, with the accuracy with the highest percentage being the accuracy that will be the diagnostic variable or the result of the expert system. A high percentage indicates that the type of disease diagnosed is more strongly influenced by symptoms and the confidence level in the symptoms entered by system users. The initial diagnosis showed that the first patient had a diagnosis of acute kidney disease with a confidence level of around 95.4944%, then based on the results of the second patient's diagnosis, the patient was identified as having kidney stones with a confidence level of 95.8%. The results of the last patient's diagnosis identified the third patient as having kidney disease. Kidney cancer with a confidence level of 95%.

It is essential to validate expert system conclusions with truth points after a diagnosis is made to diagnose kidney disease with confidence and accuracy. Diseases known as "truth points" are diseases experienced or experienced by every patient and are used as test data. Validation can show the accuracy of the expert system using the certainty factor method. Further information about the validation of test data with truth points is presented in Table VII.

Table VII. Test data validation

Test Data	Expert System Results	*Truth point*
Test Data 1 (Patient 1)	Acute Renal Failure 95.4944%	Acute Kidney Failure
Test Data 2 (Patient 2)	Kidney Stones 95.8%	Kidney stones
Test Data 3 (Patient 3)	Kidney Cancer 95%	Kidney Cancer

In the validation table, test data 1 (patient 1), test data 2 (patient 2), and test data 3 (patient 3) show compatibility between the expert system results and their point of truth. Test data 1 (patient 1) also describes relevant expert system results and corresponds to the point of truth with a high proportion of system trust. An expert system created using the certainty factor method functions well. It is accurate, as can be seen from the suitability between the findings of the testing phase and the truth points reported at the validation stage.

CONCLUSION

This journal discusses the expert system for diagnosing kidney disease using the Certainty Factor method. The Certainty Factor method evaluates the confidence level in diagnosing kidney disease. This expert system has been tested using the available sample data in this research. From the results of the tests, it can be concluded that this expert system can provide an accurate diagnosis in detecting kidney disease.

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