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# Application of the Certainty Factor and Forward Chaining Methods to a Goat Disease Expert System

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**Abstract-**Goats are livestock that is financially very attractive to rural Indonesian. Efforts to solve problems related to goat farming are necessary. One of them is maintaining the health of the cattle by knowing how to cope with disease-stricken goats. Goat productivity will decrease if the treatment of the disease is sub-optimal. Goat diseases are very diverse, ranging from mild to severe. Breeders themselves can traditionally treat several diseases without the involvement of veterinarians or experts. However, a larger number of diseases need treatment with the help of experts. Expert systems are a potential solution to help farmers. It will automatically suggest decisions or conclusions in solving a problem. This study observes an expert system built using the Certainty Factor combined with Forward-Chaining. By combining the two methods, the information generated may discover the type of disease and suggest its management effectively with a high degree of certainty. The system can expectedly become a reference for goat breeders to consult about their goat livestock diseases. The knowledge base of the system uses 21 types of symptoms, eight types of diseases, and their solutions. The user does not need to input the belief value and the disbelief value that is usually input in the expert system. By involving the admin as a knowledge base processor, the correctness of the conveyed information maintains.

**Keywords:** expert system, certainty factor, forward chaining, goats

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## 1. Introduction

Goats are livestock that are in great demand in Indonesia. One of the problems often faced by breeders is goat disease. The productivity of the goats has decreased if the handling of the disease is not optimal. There are many types of goat disease, ranging from mild to severe [1]. The disease can be treated in the traditional way by the farmer himself without having to involve a doctor or expert. If the treatment and handling of livestock is not optimal, it can result in cattle death and loss. If their livestock is sick or even dies, the breeders usually slaughter the goat before the goat dies. This makes the selling price of sick goats cheaper than healthy goats. Thus the breeders often lose money because the gain from selling the meat cannot cover the initial capital to purchase new young fresh goat.

Seeing this condition, efforts to solve the goat livestock problem are important. One of them is maintaining the health of livestock by knowing how to cope with and deal with disease-stricken goats [2]. The application of this system apart from providing information about goats also makes it easier for a breeder to carry out consultations without having to enter the value of believe (MB) and the value of disbelieve (MD).

From reference [13], there are 8 common types of goat disease, namely:

1. Worms
2. Diarrhea
3. Scabies or Ringworm
4. Tympany or Bloat
5. Pink Eye
6. Poisoning
7. Tetanus
8. Anthrax

The knowledge and experience of veterinarians or experts can be implemented into a system called an expert system. The application of doctor-like analysis skills is modeled using software on a computer. The modeling can provide problem solving suggestions as well as an expert

or a doctor [3]. Expert system is a system that combines knowledge to solve problems as is done by an expert or expert [4]. The information system can reach higher precision in narrower domain problems [5].

This expert system can be a potential solution. The system automatically provides decisions or conclusions in solving a problem [6] [14]. There are several parts to an expert system, namely the consulting and development environment. In the development section, the task of system builders is to introduce and build components into the knowledge base [7]. An expert system architecture (Arhami, M. 2005) can be seen in Figure 1.

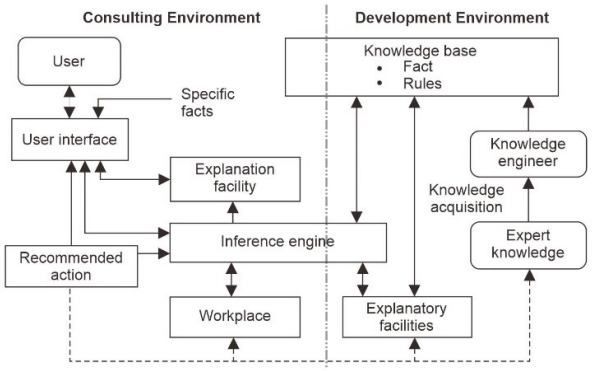


**Figure 1. Expert System Architecture.**

The method used in this expert system is *Certainty Factor*. The Certainty Factor method is used when facing a problem whose answer is uncertain. This uncertainty can be a probability. By presenting the degree of confidence and uncertainty, this method is similar to the fuzzy logic method [4]. There are several differences between the two methods, namely if the fuzzy logic conditions are more than one, the believe value only sees the lowest value in the AND operator, so that the OR value is higher for each condition. The measure of certainty in this method is in accordance with the rules and facts entered in the system [8].

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

Information:
CF[h,e] = Certainty Factor.
MB[h,e] = Measure of belief on the hypothesis with a range of values or weights 0-1.
MD[h,e] = Measure of disbelief, the hypothesis with a range of values or weights 0-1.
h = The conclusion or hypothesis is generated (between 0 - 1).
e = Facts or events (Evidence).

There are several combinations of CF against certain premises:

1. CF with one condition:
   CF[h,e] = CF[e] x CF[rule]=CF[user] x CF[expert] (2)
2. CF with more than one premise:
   CF[A and B] = Min(CF[a],CF[b]) x CF[rule] (3)
   CF[A or B] = Max(CF[a],CF[b]) x CF[rule] (4)
3. CF with a similar conclusion:
   CFcombined[CF1,CF2] = CF1+CF2 x (1-CF1) (5)

This method is very suitable to be applied to expert systems that have advantages in performing calculations. By using a measure of the degree of certainty or confidence, this method can compute with one calculation. Furthermore, the data is processed to produce accurate decisions. One example is the object of this research, namely the detection of goat disease and its solution.

The Forward Chaining method (Arhami, M. 2005) is often called bottom-up reasoning, because reasoning from facts at the lower level to conclusions at the upper level is based on facts. This method starts working by using available data and certain inference rules to get the other data to a conclusion. An inference engine that uses Forward Chaining looks for inference rules until it finds one of the correct IF - THEN hypotheses or clauses. Reasoning starts from the facts first to test whether the hypothesis is true or not. The facts in the system are stored in working memory for later continuous update [9]. The following is an example of inference using the FC method [10]. See Figure 2.

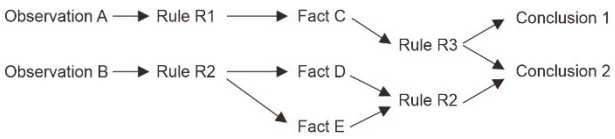


**Figure 2. Forward Chaining Process**

IF [antecedent] THEN [consequent]
IF [premise] THEN [conclusion]
IF [condition] THEN [action]

## 2. Method

### a. Research methodology

The research flow diagram can be seen in Figure 3.

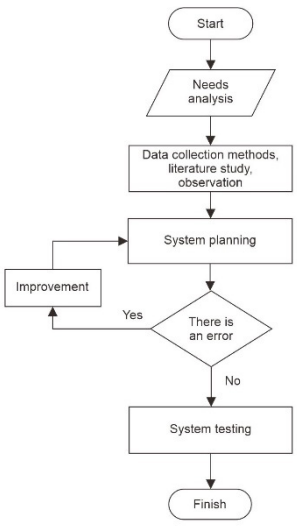


**Figure 3. Research Flowchart**

The research stage, among others:

1. Requirement analysis. Among them is the study of literature, namely understanding the theory used. This includes the type of disease, its symptoms, and its solutions [13]. Next is to determine the value of confidence (MB) and value of uncertainty (MD). Other supporting data are articles related to the object of this study, namely knowledge of goat disease.
2. Observation. This is done by directly interviewing several goat breeders to see the existing problems and taking accurate data about the goat diseases there.
3. The next process is system design, starting from determining the user interface to entering the knowledge base and rules of existing diseases and symptoms. If there is an error either in calculation or the results of the system analysis, then it will be corrected and reviewed.
4. The final step is a thorough system test. There are two access rights in this system, namely the user in conducting consultations, and the admin to manage this expert system.

### b. Knowledge Base

This system uses a knowledge base as a data base regarding disease facts, symptoms facts, and solutions. Symptoms of disease that are processed in the expert system for diagnosing goat disease are 8 types of disease and 21 kinds of symptoms. These facts can be seen in Table 1 and Table 2.

**Table 1. Types of diseases**

| Disease Code | Name of Disease |
|---|---|
| P001 | Worms |
| P002 | Diarrhea |
| P003 | Scabies or Ringworm |
| P004 | Tympany or Bloat |
| P005 | Pink Eye |
| P006 | Poisoning |
| P007 | Tetanus |
| P008 | Anthrax |

**Table 2. Symptom**

| Symptom Code | Symptom name |
|---|---|
| G001 | The cattle looks lethargic, weak, pale |
| G002 | Decreased appetite |
| G003 | Goat diarrhea, enlarged stomach and hair standing up and dull |
| G004 | Goat manure is light green, shiny, or reddish, or blackish in color. |
| G005 | The skin appears red spots that form boils so that it experiences stiffness, thickening, and scaling. |
| G006 | Skinny cattle |
| G007 | Cattle rubbed their skins against the barn because it was itching and looked like they were losing their hair |
| G008 | Livestock have difficulty breathing |
| G009 | The left side of the stomach looks big, if it is tapped it will sound like a drum |
| G010 | Livestock seems restless |
| G011 | Cattle fall and find it difficult to get up again |
| G012 | The eyes ooze and flicker |
| G013 | The eyes are red and swollen |
| G014 | Ulcers appear on the clear membrane until you experience blindness |
| G015 | Livestock convulsions |
| G016 | The mouth is frothy, the mucous membranes of the eyes are bluish, |
| G017 | Stool mixed with blood |
| G018 | Cattle have high fever |
| G019 | Part of his body became stiff |
| G020 | Swollen pectoral glands, chest full of ulcers |
| G021 | Removes blood from the ears, mouth and anus |

### c. Results of Certainty Factor Data

The application of the CF method requires several variables, namely the weighted value of the MB (measure of believe) and MD (measure of disbelieve). Each symptom will be given a weight or confidence value according to its confidence level, between 0 and 1. The rule of symptoms against the type of disease that is present will be used as the knowledge base in the system.

The data is taken from reference book [13]. The data is entered into the expert system's knowledge base and adjusted for the weight or confidence value of each symptom. This value or weight is between 0-1, by looking at the symptoms that appear in goats. There were 8 types of diseases included in the knowledge base, which were accompanied by their solutions and treatments.

Following are the symptoms of the disease along with the MB and MD values that were entered into the expert system. Including the type of disease and the rule of symptoms for each type of disease. See Table 3.

**Table 3. Disease and symptom data with weighted scores**

| Disease code | Symptom code | Symptom name | MB | MD |
|---|---|---|---|---|
| P01 | G001 | The cattle look lethargic, weak, pale | 0,9 | 0,1 |
| | G002 | Decreased appetite | 0,9 | 0,1 |
| | G003 | Goat diarrhea, enlarged stomach and hair standing up and dull | 1 | 0,1 |

| Disease code | Symptom code | Symptom name | MB | MD |
|---|---|---|---|---|
| P02 | G001 | The cattle looks lethargic, weak, pale | 0,8 | 0,2 |
| | G004 | Goat manure is light green, shiny, or reddish, or blackish in color. | 1 | 0 |
| P03 | G005 | The skin appears red spots that form boils so that it experiences stiffness, thickening, and scaling. | 0,9 | 0,1 |
| | G006 | Skinny cattle | 0,8 | 0,2 |
| | G007 | Cattle rubbed their skins against the barn because it was itching and looked like they were losing their hair | 0,9 | 0,1 |
| P04 | G008 | Livestock have difficulty breathing | 0,8 | 0,2 |
| | G009 | The left side of the stomach looks big, if it is tapped it will sound like a drum | 0,9 | 0,1 |
| | G010 | Livestock seems restless | 0,8 | 0,2 |
| | G011 | Cattle fall and find it difficult to get up again | 0,8 | 0,2 |
| P05 | G012 | The eyes ooze and flicker | 0,9 | 0,1 |
| | G013 | The eyes are red and swollen | 0,8 | 0,2 |
| | G014 | Ulcers appear on the clear membrane until you experience blindness | 0,8 | 0,2 |
| P06 | G015 | Livestock convulsions | 0,8 | 0,2 |
| | G016 | The mouth is frothy, the mucous membranes of the eyes are bluish, | 1 | 0 |
| | G017 | Stool mixed with blood | 0,9 | 0,1 |
| P07 | G015 | Livestock convulsions | 0,8 | 0,2 |
| | G018 | Cattle have high fever | 0,9 | 0,1 |
| | G019 | Part of his body became stiff | 1 | 0 |
| P08 | G020 | Swollen pectoral glands, chest full of ulcers | 0,8 | 0,2 |
| | G021 | Removes blood from the ears, mouth and anus | 0,9 | 0,1 |

### d. Forward Chaining Data Results

The FC method is a search technique that starts with known facts, then matches those facts with the IF part of the IF – THEN rules. If there are facts that match the IF part, the rule is executed. When a rule is executed, a new fact (THEN section) is added to the database. The following is a rule of symptoms for each type of disease. See Table 4.

**Table 4**. Rule of Disease and Symptoms

| Disease code | Rule |
|---|---|
| P01 | If G01 And G02 And G03 Then P01 |
| P02 | If G01 And G04 Then P02 |
| P03 | If G05 And G06 And G07 Then P03 |
| P04 | If G08 And G09 And G010 And G11 Then P04 |
| P05 | If G12 And G13 And G014 Then P05 |
| P06 | If G15 And G16 And G017 Then P06 |
| P07 | If G15 And G18 And G019 Then P007 |
| P08 | If G20 And G21 Then P08 |

## 3. Result and Discussion

Further analysis is needed to determine the comparison between manual testing and real testing on the system so that the effectiveness of this application can be determined. The question is how accurate the *Certainty Factor* and *Forward Chaining* methods are in detecting goat disease.

### a. Analysis Stages

The following are the requirements for these two types of system users:

1. Requirements of users or breeders.

User access rights are to view the main page of the system, which is information about the health of goats and register for further disease consultation.

2. Admin Requirements.

Admin access rights include entering knowledge data including types of diseases, symptoms, and solutions. Furthermore, managing the knowledge base, namely entering the rules of disease and symptoms. Then the admin enters the MB and MD values to be part of the knowledge base.

### b. Sample case

Farmer X makes a diagnosis through an expert system, by entering the symptoms that arise, as shown in Table 5.

**Table 5. Examples of symptom cases entered by X**

| Numb | Symptom Name | Answer |
|---|---|---|
| 1 | The cattle looks lethargic, weak, pale | √ |
| 2 | Decreased appetite | √ |
| 3 | Goat got diarrhea, enlarged stomach and hair standing up and dull | √ |
| 4 | Goat manure is light green, shiny, or reddish, or blackish in color. | |
| 5 | The skin appears red spots that form boils so that it experiences stiffness, thickening, and scaling. | |
| 6 | Skinny cattle | √ |
| 7 | Cattle rubbed their skin against the barn because it was itchy and their hair appeared to fall out | |

| Numb | Symptom Name | Answer |
|---|---|---|
| 8 | Livestock have difficulty breathing | |
| 9 | The left side of the stomach looks big, if it is tapped it will sound like a drum | |
| 10 | Livestock feel restless | |
| 11 | Cattle fall and find it difficult to get up again | |
| 12 | The eyes ooze and flicker | |
| 13 | The eyes are red and swollen | |
| 14 | Ulcers appear on the clear membrane until you experience blindness | |
| 15 | Livestock convulsions | |
| 16 | The mouth is frothy, the mucous membranes of the eyes are bluish | |
| 17 | Stool mixed with blood | |
| 18 | Cattle have high fever | |
| 19 | Part of his body became stiff | |
| 20 | Swollen pectoral glands, chest full of ulcers | |
| 21 | Removes blood from the ears, mouth and anus | |

Problem solving:

Possibilities 1. Having **worms** due to the symptoms that exist in the knowledge base is that the livestock looks lethargic, weak, pale, decreased appetite, goat diarrhea, enlarged stomach and hair stands up and dull.

There are 3 symptoms that appear, so equation (5) is used to determine the value of Certainty Factor because in this calculation the user does not enter the user's weight. The weight used is in accordance with the expert's weight that has been entered into the system.

CF[h,e]g1=MB[h,e]g1-[MD[h,e]g1
= 0,9-0,1
= 0,8
CF[h,e]g2=MB[h,e]g2-[MD[h,e]g2
= 0,9-0,1
= 0,8
CF[h,e]g3=MB[h,e]g3-[MD[h,e]g3
= 1-0
= 0,9
CFcombined1[CF1,CF2]= CF1+CF2*(1-CF1)
= 0,8+0,8*(1-0,8)
= 1,6*0,2
= 0,32
CFcombined2[CFold1,CF3]= CFold1+CF3*(1-CFold1)
= 0,32+0,9*(1-0,32)
= 1,22*0,68
= 0,83

Note: CFcombined1 or CFold1 is the calculation of the similarity of symptoms of G01 and G02. CFcombined2 or CFold2 is the result of the calculation of Case 1 by Mr. Wawan is 0.83. Furthermore, the calculation of the percentage of confidence in disease is:

Percentage = CFdisease*100
= 0,83*100
= 83%

Possibility 2. Affecting **Scabies** or **Ringworm**: because the symptoms that exist in the knowledge base are lean cattle.

The number of symptoms that appear is 1, then equation (1) is used to determine the value of Certainty Factor because in this calculation the symptoms that appear are only 1 for P03 disease. The weights used by MB and MD are in accordance with expert weights and uncertainty weights that have previously been entered into the system.

CF[h,e]=MB[h,e]-[MD[h,e]
= 0,8-0,2
= 0,6

Note: CF [h, e] is the certainty factor obtained from the calculation of MB [h, e] -MD [h, e], namely the weight of certainty minus the weight of uncertainty. Furthermore, the calculation of the percentage of confidence in disease is:

Percentage = CFdisease *100
= 0,6*100
= 60%

### c. System Test Results

The system test stage is the calculation process in the case sample will be compared with the system test results. The results of the system testing will later be used as a reference as a tool for detecting goat disease. There are several menus in this expert system:

1. Expert Main Menu.
   This menu is used by the admin to enter the knowledge base, including types of diseases, symptoms and expert weight, and rules. The main menu of the expert system can be seen in Figure 4.

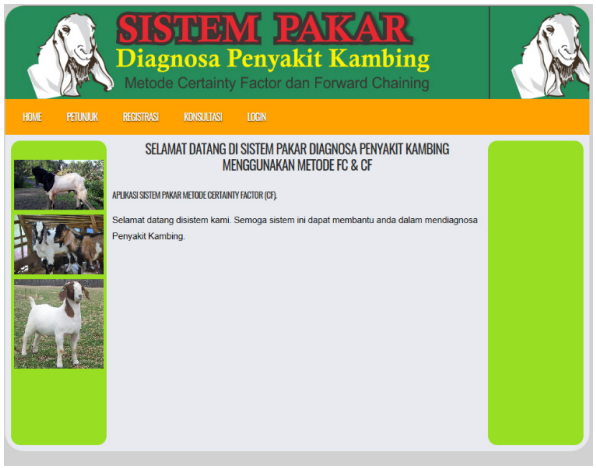


**Figure 4. Expert System Main Menu.**

This menu is the main view of the expert system. Access rights from this menu are the user as the

breeder who will carry out the consultation, and the admin as the knowledge base processor.

2. Admin Menu.
   This menu is used by the admin to enter the knowledge base (such as types of disease, symptoms with weight, solutions, and rules for Forward Chaining), as well as to manage admin login. Expert system admin menu can be seen in Figure 5.


**Figure 5. Admin menu.**

Admin as the main maintainer of the system can enter the knowledge base, including types of diseases, types of symptoms, solutions, rules of disease and symptoms and the value of MB and MD.

3. User Registration Menu.
   This menu is used for user registration by entering some data, including patient code, name, age, gender, address, username, and password. The expert system user registration menu can be seen in Figure 6.


**Figure 6. User Registration Menu.**

This menu is used by users to register personal data before consulting.

4. User Consultation Menu.
   This menu is used by users (who are already registered) to carry out health consultations. The consultation menu can be seen in Figure 7.

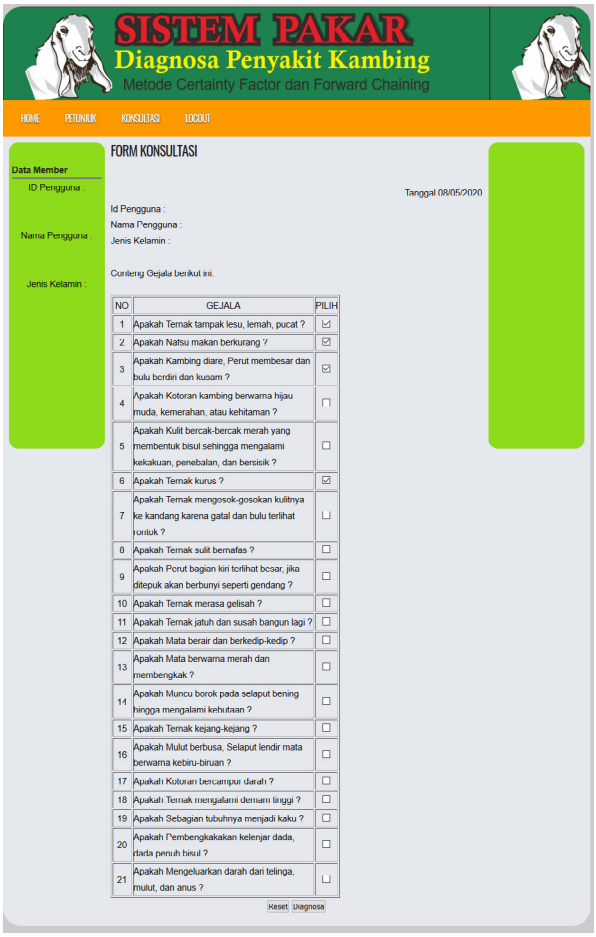


**Figure 7. User Consultation Menu.**

This menu displays the symptom data that appears and then the user makes a checklist according to the complaints experienced by the livestock.

5. Consultation Result Menu.
   This menu displays the results of diagnoses that have been carried out by the user so as to produce data on the results of diseases and their prevention or control. The results of the calculation manually gave a diagnosis result in the form of worms with a percentage of 83%. The results of diagnosis using this system can be seen in Figure 8.

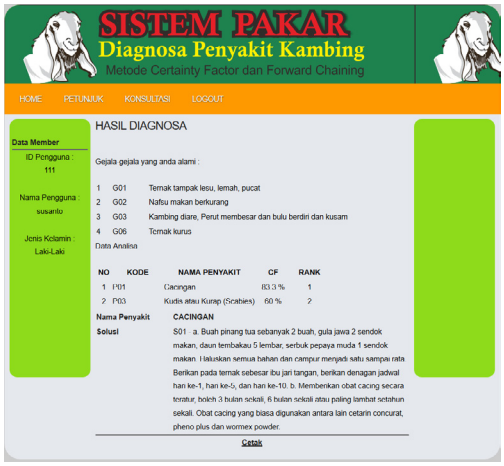


**Figure 8. Consultation Result Menu.**

This menu displays the results of the consultation in the form of types of diseases that may be infected and their solutions.

### c. Discussion

Scenario testing is done by analyzing the results of possible diseases that arise. With manual calculations the results obtained are 83% for worms and 60% for scabies or ringworm. Manual testing is only to show that the rules or relations of disease and symptoms are in accordance with the knowledge base created using the Forward Chaining method. While the Certainty Factor is used to display the percentage value to show the level of confidence that exists in the system that has been entered.

Previous research [11] has several drawbacks, among others, the types of symptoms that appear in the system are not fully visible. The only symptom displayed is one symptom then the user selects Yes or No. While research [12] involved disease data, symptom data and training data, however, rule data were not included. So that the error rate in analyzing the results can still be high.

The combination of the Certainty Factor and Forward Chaining methods is expected to display a user interface that is simpler and easier to run. The result of the percentage of system analysis shows the level of accuracy which will also be displayed on the system. In this case an accuracy rate of 83% was obtained. The percentage only represents the calculation of the example cases above.

## 4. Conclusion

Based on the explanation above, it can be concluded that the application of the Certainty Factor and Forward Chaining methods is able to analyze the query results to the user during consultation, without the user needing to enter the MB and MD values.

The processing of the rule base and knowledge base can only be done by an admin or an expert. Restrictions on access rights for knowledge bases and rule bases are the full rights of administrators or experts so that the correctness of knowledge data information is maintained.

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