The Analysis of Comparison of Expert System of Diagnosing Dog Disease by Certainty Factor Method and Dempster-Shafer Method

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Abstract

Expert system is one of branches of artificial intelligence that studies how to "adopt" an expert way of, inferring from a number of facts, and making decision. This paper presents a comparison between two methodologies, Certainty Factor Method and Dempster-Shafer Method to identify diseases of the dog. Providing proper health care can be done by knowing common dog diseases and being aware of appropriate prevention and treatment. In this paper used 74 physical symptoms of illness to find 17 types of common diseases of dogs. Five options are given to answer questions of calculations using each method: no, quite sure, pretty sure, sure, and definitely sure. The accuracy of the analysis of each method was tested by assessing the results of each analysis method based on the given user enter. The results of the analysis are correct when judged from the point of view of experts.

Keywords: *Diseases of Dog, Certainty Factor Method, Dempster-Shafer Method.*

1. Introduction

Dogs are animals which can adapt easily and can be a good friend to human, so that many of them are cared. High interest to get a dog cause many keepers need information on how to protect and care of their dog easily without going to a clinic or veterinarian. Some of the most common and serious dog diseases have been made less common through vaccines. However, these diseases threaten a dog that lacks proper immunization. [dog] In addition, there are many dog owners who do not pay attention to their pets health because much cost of bringing dog to the vet and the existence of veterinarian itself which is still lack. Carelessness in maintaining a dog can result in losses to the breeder and the surrounding communities. One of the examples is rabies disease which is transmitted very quickly and even can cause death to humans or animals. Some dog diseases can also be easily transmitted to humans. Veterinary experts, in this case, has the ability to analyze the symptoms of the disease, but to overcome any problems the dog caretaker constrained by time and the widespread of deployment to the animal.

Expert System is a reasoning system that performs comparable to or better than a human expert within a particular domain.[12] The basis of expert system is how to move the knowledge possessed by an expert into a computer and how to infer or make decisions based on that knowledge. Storing the knowledge into computer needs a database of knowledge (Knowledge Base) that is database modeling determined in advance. Expert systems are used by doctors to help with evidences that are hard to diagnose and to suggest preventive measures or measures self care where even human experts have difficulty [1].

There are several approaches that can be used in building an expert system. One approach that seems right for the case of diagnosis of disease is by using reasoning with uncertainty. This is because of many of the conditions or circumstances that are not entirely certain when diagnosing a disease. Expert systems created to help people in decision making that must be designed with the ability to cope with these uncertain domains [2]. A number of approaches can be used relating to this uncertainty, such as Certainty Factor (CF). In this method, in expressing the degree of confidence, a value called the certainty factor (CF) to assume a degree of belief in an expert to the data is used. Certainty Factor introduces the concept of belief and disbelief. For reason about degrees of certainty, CF is used. The second method will be used is Dempster-Shafer method. Dempster-Shafer method is based on two ideas, the first idea is to obtain a degree of belief for one question from subjective probabilities for a related question, and the second is the rule for combining belief which is based on a degree of evidence. There are three important functions in the Dempster-Shafer theory, namely: basic probability assignment function (BPA or m), Belief function (Bel), and the Plausibility function (Pl). Both of these approaches will be used, which is then compared which diagnosis result has the highest degree of accuracy close to the diagnosis of an expert.

The importance of information about the disease on dogs is based on the symptoms of the disease and ways to overcome, so this paper will discuss the application of expert system to diagnose the disease on dogs by Dempster-Shafer method and Certainty Factor that can later be used to reduce and minimize the risk of death. With the hope of the expert system can help as a veterinarian to identify diseases of the dog.

2. Methodology

The overview diagram of this research is shown in Fig. 1.

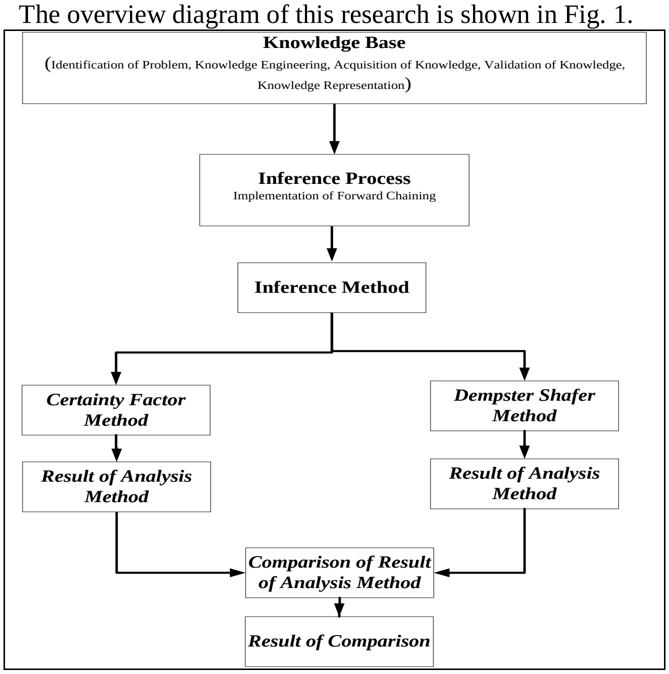

Fig. 1 General Overview System

2.1 Knowledge Base

In this paper, the problem identification process is carried out which will be made the expert system of it. In this case problem tried to explore is the disease in dogs. After a literature study of this problem is taken, the problems seen in this disease of dogs is that it can no longer be underestimated, because there are diseases that can cause death in dogs and even death in humans such as rabies which has been widespread.

Knowledge Engineering is a knowledge base development activity that will be integrated into the expert system. This knowledge base will be used as a basis of knowledge of the system in doing the reasoning. The stages performed in knowledge engineering in an expert system to diagnose the disease in dogs use Dempster-Shafer method and the Certainty Factor method; it consists of knowledge acquisition process, knowledge validation process, knowledge representation process, and conclusions or inferences.

In the process of knowledge acquisition, a knowledge engineer will attempt to gather relevant knowledge by expert systems to be built. Collection of knowledge is done by studying books and other references relating to the problems of disease in dogs, but it is also carried an interview with the vet to get an explanation and more knowledge about the disease. The knowledge gained is then transformed by the knowledge engineer into the knowledge base. Basically the process of acquiring this knowledge is the bridge between the expert and the knowledge base.

This process is the stage where the knowledge base that has been built on the knowledge acquisition phase will be validated by experts whether the knowledge that has existed was appropriate and proper or not. If it turns out that knowledge is not appropriate yet, then re-acquisition of knowledge will be done by the addition or reduction in the knowledge base to a knowledge base that is valid and in accordance with the approval of experts. If the expert has given its approval that the existing knowledge base is the right one then the process continues to the stage of knowledge representation.

Having knowledge successfully acquired and validated by experts, knowledge which has acquired needs to be organized and arranged in a configuration with a particular format or representation. The goal is to make the system easier to access the existing knowledge, so it can be used as a basis for finding a solution. A popular knowledge representation method is production rules and frames. In the expert system to diagnose the disease in dogs is used a production rule from the tree model as a knowledge representation method.

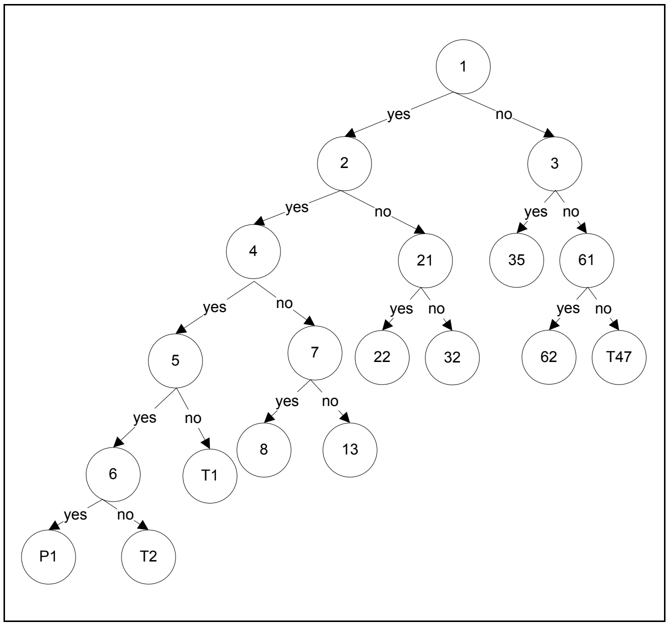

Fig. 2 Modeling knowledge base of diseases of dog with tree

Description of the tree above:

1 : Does your dog look sluggish or feeble?
2 : Is your dog's appetite decreasing?
4 : Is your dog having yellowish (mucous membrane jaundice)?
5 : Is your dog experiencing dehydration (increasing thirst)
6 : Is your dog issued peeing blood?
P1 : Your dog is diagnosed having leptospirosis disease.
21 : Is your dog's attitude and behavior changing?
22 : Is your dog's tail folded in?
32 : Is your dog experiencing diarrhea with yellow to green?
7 : Is there a liquid or viscous rheum in the nose (flu) on your dog?
8 : Is there any rheum on your dog's eyes?
13 : Is there any thickening on your dog's skin?
T1 : Your dog is may be diagnosed having leptospirosis disease.
T2 : Your dog is may be diagnosed having leptospirosis disease.
3 : Is your dog having a fever (body temperature is above 37 ° C)
35 : Is your dog experiencing bloody diarrhea?
61 : Is your dog experiencing to be itchy?
62 : Is your dog's skin experiencing redness?
T47 : No disease found.

It can be seen on modeling base knowledge of dog disease with tree diagram like the in Fig. 2, notation "yes" means node (evidence) fulfill the node (evidence) above it; "no" means the node (evidence) doesn't fulfill the previous node (evidence) above it. Hypotheses P1 will be achieved if there is evidence 1,2,4,5 and 6. Each node represents certain evidence for each condition "yes" and "no", so that there will be no node leading to the same evidence. In diagnose session, this means each answer is different from the user; therefore, it leads to different question.

2.2 Certainty Factor Method

Certainty Factor is introduced by Shortliffe Buchanan in making MYCIN (Kusumadewi, 2003). Certainty Factor (CF) is a clinic parameter value which is given by MYCIN to show the measurement of belief. Certainty Factor (CF) shows the measurement of certainty to a fact or rule.
The using of certainty factor is done for: [2]

1. Determining the measurement of belief to the early fact which will be given by every user,
2. Determining the measurement of belief to conclusion or decision which is obtained from the rule; experts determine this value to the rule,
3. Determining the measurement of belief to facts and result which is obtained along the process of reasoning from the result of the rule execution,
4. Adjusting the measurement of belief to fact or result which is obtained from the different rule but producing the same conclusion.

Certainty factor is defined as below:

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

With:
CF [h,e] = Certainty Factor
MB [h,e] = Measurement of Belief to hypothesis *h*, if given evidence *e* (between 0 and 1)
MD [h,e] = Measurement of Disbelief to hypothesis *h*, if given evidence *e* (between 0 and 1)

The following is the description of some combinations of Certainty Factor to any conditions:

1. Certainty Factor for single premise rules:
   CF (H, E) = CF (E)*CF (rule)
   = CF(user)*CF(expert)...................(2)
2. Certainty Factor for multiple premise rules:
   CF (A AND B) = Minimum (CF (a), CF (b)) * CF (rule)
   CF (A OR B) = Maximum (CF (a), CF (b)) * CF (rule)
3. Certainty Factor for similar concluded rules:
   CF COMBINE(CF1,CF2)= CF1 + CF2*(1-CF1)........(3)

Calculating process of belief percentage is done by the following steps:

1. Determining rule based on basic knowledge
2. Solving rule which has multiple premise rule to be single premise rule

3. Calculating value of CF expert with the value of mb and md in every symptoms using equation (1)
4. Calculating value of CF in every rule using equation (2) to get the value of CF in every rule
5. Then the value of CF is combined to equation (3)

Example for the experiment using Certainty Factor Method:
First experiment is performed using Certainty Factor Method. User will be given five choices of answers to answer every question such as the following table.

Table 1: Certainty Value for User

No	0
Quite Sure	0,4
Pretty Sure	0,6
Sure	0,8
Definitely Sure	1

Value 0 shows that the patient does not experience symptoms of the disease which is asked by the system. The more the patient sure that he is indeed experiencing the symptoms, so that the larger the percentage of total belief that the results will be obtained.

Rule 1:
IF Look lethargic / weak
AND decreased appetite
AND Mucous membranes jaundice (yellowish)
AND Dehydration (increased thirst)
AND Bloody urine
THEN Leptospirosis

First step, the expert determines the CF value of every evidences as follows:
CFexpert(look lethargic / weak)
= mb – md
= 0,7 – 0,1 = 0,6
CFexpert(decreased appetite)
= mb – md
= 0,6 – 0,1 = 0,5
CFexpert(Mucous membranes jaundice (yellowish)
= mb – md
= 0,7 – 0,1 = 0,6
CFexpert(dehydration (increased thirst))
= mb – md
= 0,6 – 0,1 = 0,5
CFexpert(bloody urine)
= mb – md
= 0,8 – 0,1 = 0,7

For example the user choosing answers as follows:
Look lethargic / weak: Maybe = 0,4
Decreased appetite: Probably= 0,6
Mucous membranes jaundice (yellowish): Maybe = 0,4
Dehydration (increased thirst): Probably = 0,6
Bloody urine: Certainly = 0,8
Early rule which has 5 premises is changed into rule which has single premise to be:
Rule 1.1
IF Look lethargic / weak
THEN Leptospirosis
Rule 1.2
IF Decreased appetite
THEN Leptospirosis
Rule 1.3
IF Mucous membranes jaundice (yellowish)
THEN Leptospirosis
Rule 1.4
IF Dehidration (increased thirst)
THEN Leptospirosis
Rule 1.5
IF Bloody urine
THEN Leptospirosis

Then the CF value of the rules is calculated using the equation below:
CF (H, E) = CF (E)*CF (rule)
= CF (user)*CF (expert)

CF 1.1 = 0,4 * 0,6 = 0,24
CF 1.2 = 0,6 * 0,5 = 0,30
CF 1.3 = 0,4 * 0,6 = 0,24
CF 1.4 = 0,6 * 0,5 = 0,30
CF 1.5 = 0,8 * 0,7 = 0,56

Combine the value CF 1.1 to value CF 1.2 using the formula below:
CF COMBINE (CF1,CF2)= CF1 + CF2*(1-CF1), so it becomes
CF COMBINE (CF 1.1, CF 1,2) = 0,24 + 0,30*(1-0,24)
= 0,46 = CFold
Combine CFold to CF 1.3 as follows:
CF COMBINE (CFold,CF 1.3) = 0,46 + 0,24*(1-0,46)
= 0,58 = CFold

Combine CFold to CF 1.4 as follows:
CF COMBINE (CFold,CF 1.4) = 0,58 + 0,30*(1-0,58)
= 0,70 = CFold
Combine CFold to CF 1.5 as follows:
CF COMBINE (CFold,CF 1.5) = 0,70 + 0,56*(1-0,70)
= 0,86

Belief percentage = CF COMBINE * 100%
= 0,86 * 100%
= 86%
So belief system percentage against leptospirosis disease is 86% according to the answer given by the user.

2.3 Dempster-Shafer Method

Dempster-shafer method is first introduced by Dempster, who did an experiment to an uncertainty model with probability range as a single probability. Then in 1976, Shafer published the Dempster theory in a book entitled Mathematical Theory of Evident. A way to reason about degrees of belief is provided by Dempster-Shafer method. [1]
Generally, Dempster-Shafer is written in an interval: [3]

[Belief, Plausibility]......................(4)

Belief (Bel) is measurement of evidence power in supporting a proposition assemblage. If it is worth 0 (zero), it indicates that there is no evidence; if it is worth 1, it shows that there is certainty. According to Giarratano and Riley, the function of belief can be formulated as:

$$Bel(X) = \sum_{Y \subseteq X} m(Y) \quad \text{.....................(5)}$$

While *Plausibility* (Pls) is denoted as:

$$Pls(X) = 1 - Bel(X') = 1 - \sum_{Y \subseteq X'} m(X') \quad \text{.............(6)}$$

Where:
Bel(X) = Belief (X)
Pls(X) = Plausibility (X)
M(X) = mass function of (X)
m(Y) = mass function of (Y)

In Dempster-Shafer theory, the set of the universe of discourse of a set of hypotheses given the notation θ , where it is assumed that the hypotheses used is grouped to an individual environment. To show how big the belief of evidence to a certain hypotheses is called probability density function which is given notation (m).

In the application of expert system in a disease, there is some evidence which will be used to uncertainty factor in taking decision for diagnosis of a disease. To solve that some evidence in Dempster-Shafer theory, it is used a rule known as Dempster's Rule of Combination.

$$m1 \oplus m2(Z) = \frac{\sum_{X \cap Y = Z} m1(X) m2(Y)}{1 - \sum_{X \cap Y = \theta} m1(X) m2(Y)}. \quad \text{......................(7)}$$

Where:

$m1 \oplus m2(Z)$ = mass function of evidence (Z)
$m1(X)$ = mass function of evidence (X)
$m2(Y)$ = mass function of evidence (Y)
K = the amount of evidential conflict

Calculating process of belief percentage is done by the following steps:
1. Determining rule based on basic knowledge
2. Determining value of density (m) and m(θ) = 1- m1{x} using equation (9)
3. Calculations using Dempster's Rule of Combination using equation (11)
4. Determining the greatest density with Max { m {}}

Example for the experiment using Dempster-Shafer Method :

In the case of diagnostics, user answered five evidence, include look lethargic or weak, decreased appetite, mucous membranes jaundice (yellowish), dehydration (increased thirst), and bloody urine.
Rule:
IF Look lethargic / weak
AND Decreased appetite
AND Mucous membranes jaundice (yellowish)
AND Dehydration (increased thirst)
AND Bloody urine
THEN Leptospirosis

Known:
θ = {P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P11, P12, P13, P14, P15, P16, P17}

There is evidence el which support the hypotheses P1,P2,P3,P4,P5,P6,P7,P8,P10 with m = 0,60, so it can be written as follows:
m_1 { P1,P2,P3,P4,P5,P6,P7,P8,P10 } = 0,60
m_1 {θ} = 1-0,60 = 0,40

Then, there is evidence e2 which supports P1,P2,P3,P4,P5 with m = 0,60, so it can be written as follows:
m_2 {P1, P2, P3, P4, P5 } = 0,60
m_2 {θ}= 1-0,60 = 0,40

First, perform calculation to the first evidence (el) and the second evidence (e2) using equation *Dempster's Rule of Combination* to overcome a number of evidence showed up and get a new m value, as follows:

Table 2: Combination e1 and e2

	{ P1,P2,P3, P4,P5 } 0,60	θ 0,40
{ P1,P2,P3,P4, P5,P6,P7, P8,P10} 0,60	{ P1,P2,P3, P4,P5 } 0,36	{ P1,P2,P3,P4, P5,P6,P7, P8,P10 } 0,24
Θ	{ P1,P2,P3,P4,P5	θ

	}	
0,40	0,24	0,16

By using the *Dempster's Rule of Combination* equation, found value of m_3 as follows:
m_3 {P1, P2, P3, P4, P5} = (0,36+0,24)/(1-0) = 0,60
m_3 {P1,P2,P3,P4,P5,P6,P7,P8,P10} = (0,24)/(1-0) = 0,24
m_3 {θ} = (0,16)/(1-0) = 0,16

Then, emerge the third evidence (e4) which supports P1 with m = 0,70, so it can be written as follows:
m_4 {P1} = 0,70
m_4 {θ} = 1-0,70 = 0,30

Conducted calculation using *Dempster's Rule of Combination* equation to get m_5 as follows:

Table 3: Combination with e4

	0,70 { P1 }	0,30 θ
{ P1,P2,P3, P4,P5 } 0,60	{ P1 } 0,42	{ P1,P2,P3, P4,P5 } 0,18
{ P1,P2,P3,P4, P5,P6,P7, P8,P10 } 0,24	{ P1 } 0,17	{ P1,P2,P3,P4, P5,P6,P7, P8,P10 } 0,072
Θ 0,16	{ P1 } 0,112	θ 0,05

So m_5 can be as followed:
m_5 {P1} = (0,42+0,17+0,112)/(1-0) = 0,702
m_5 {P1, P2, P3, P4, P5} = (0,18)/(1-0) = 0,18
m_5{P1,P2,P3,P4,P5,P6,P7,P8,P10}=(0,072)/(1-0)= 0,072
m_5 {θ} = (0,05)/(1-0)= 0,05

Then conducted the fourth evidence (e5) which supports P1 with m = 0,60, so it can be written as follows:
m_6 {P1} = 0,60
m_6 {θ} = 1-0,60 = 0,40

Conducted the calculation using *Dempster's Rule of Combination* equation to m_7 as follows:

Table 4: Combination with e5

	0,60 { P1 }	0,40 θ
{ P1 } 0,702	{ P1 } 0,42	{ P1 } 0,28
{ P1,P2,P3, P4,P5 } 0,18	{ P1 } 0,108	{ P1,P2,P3, P4,P5 } 0,072
{ P1,P2,P3,P4, P5,P6,P7,P8,P10} 0,072	{ P1 } 0,043	{ P1,P2,P3,P4, P5,P6,P7,P8,P10} 0,029
θ 0,05	{ P1 } 0,024	θ 0,016

So m_7 can be as followed:
m_7 {P1} =(0,42+0,108+0,043+0,024+0,28)/(1-0) = 0,875
m_7 {P1, P2, P3, P4, P5} = (0,072)/(1-0)= 0,072
m_7{P1,P2,P3,P4,P5,P6,P7,P8,P10}=(0,029)/(1-0)= 0,029
m_7 {θ} = (0,016)/(1-0) = 0,016

After that, the next evidence showed up is e6 which supports P1 with m= 0,70, so it can be written as follows:
m_8 {P1} = 0,70
m_8 {θ} = 1-0,70 = 0,30

Conducted calculation using *Dempster's Rule of Combination* equation to get m_9 as follows:

Table 5: Combination with e6

	0,70 { P1 }	0,30 θ
{ P1 } 0,875	{ P1 } 0,62	{ P1 } 0,26
{ P1,P2,P3,P4,P5 } 0,072	{ P1 } 0,0504	{ P1,P2,P3,P4,P5 } 0,0216
{ P1,P2,P3,P4, P5,P6,P7,P8,P10 } 0,029	{ P1 } 0,0203	{ P1,P2,P3,P4, P5,P6,P7,P8,P10 } 0,0087
Θ 0,016	{ P1 } 0,0112	θ 0,0048

So m_9 can be as followed:
m_9 {P1} = (0,53+0,0504+0,0203+0,0112)= 0.962
m_9 {P1, P2, P3, P4, P5} = (0,0216)/(1-0)=0,0216
m_9{P1,P2,P3,P4,P5,P6,P7,P8,P10}= (0,0087)/(1-0)= 0,0087
m_9 {θ} = (0,0048)/(1-0)= 0,0048

From the result of the calculation of probability value above, obtained the biggest density is m_9 { P1 } that is 0,962. Thus, its can be concluded that *user* most likely suffered P1 that is Leptospirosis with belief percentage is 0,962 * 100 % = 96,2 % according to answer which is given by *user*.

3. Experiments and Results

In the experiment, Fig. 3 shows early view of disease diagnose that will be done. System will show the first question which is always being the root of the tree of decision. Five choices of answer will be provided to answer each question; no, quite sure, pretty sure, sure, and definitely sure. Each choice of answer has quality that will be used later in the process of calculation of each method. Answer "no" means user's dog do not experience symptom which was asked by the system. The higher is rate of certainty of the user toward symptom that is experienced, so that the higher is the percentage of certainty which will be produced.

Fig. 3 System shows the first question

After the system shows the first question such as in Fig. 3, so that the user has to answer one of five choices of answer that is given by the system, it can be seen in Fig. 4

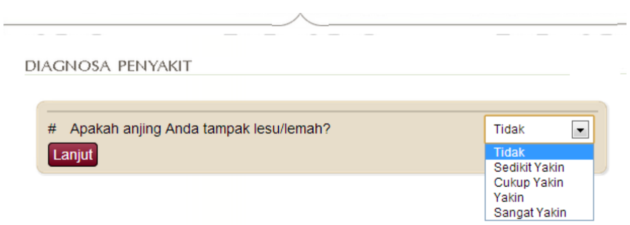

Fig. 4 Five possible answers

As the first example, if the user chooses "quite sure" on the first question, so that there will be the next question as showed in Fig. 5. The next question that will be shown is based on base knowledge modeling which has been made in a tree model. If on the first question the user answered "no", the next question which will be shown will not be the same as the question when the user answers "quite sure". In fig. 5, it is shown the next question when user answers "quite sure" and in fig. 6 will show the next question when user answers "no".

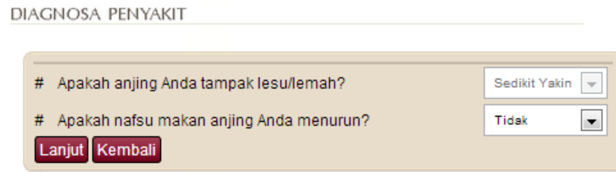

Fig. 5 The user chooses "quite sure" on the first question

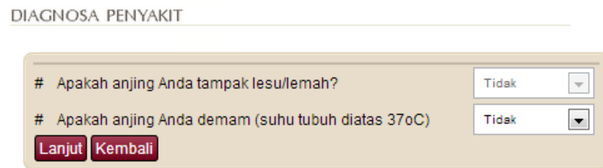

Fig. 6 The user chooses "no" on the first question

The following questions showing up depend on each answer from the user. For each different answer, there will also be different that will be shown. Each question refers to a conclusion that is based on the rules that has been determined.

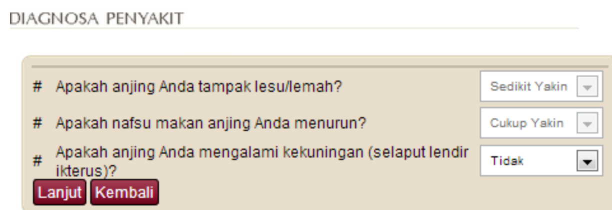

Fig. 7 The following question

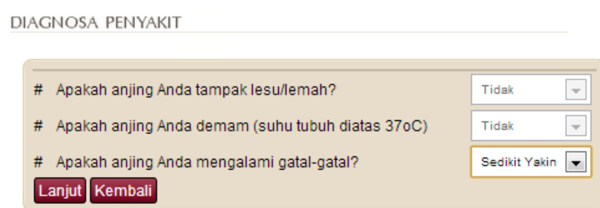

Fig. 8 The following question

System will stop showing questions if the system has found a conclusion. The conclusion is in a form of diagnose result given by the system from each user's answer. The conclusion shown is kind of disease that suffered by the user's dog and certainty value produced from Certainty Factor and Dempster-Shafer method calculation. It can be seen in Fig. 9. The system has been success in giving the diagnose result (conclusion).

Fig. 9 The diagnose result

Fig. 10 The diagnose result

Based on the Fig. 9 and Fig.10 above, there was difference result showed by using Certainty Factor and Dempster-Shafer Method. differences seen by the result of belief presentage which obtained by the calculation of each method.

Certainty factor method has simpler calculation than dempster-shafer method because the calculation in certainty factor method just involving values from mb and mb from each question. Whereas, on dempster shafer method, the calculation is done by considering value from each disease possibilities.

Dempster-shafer method, in determining percentage result of belief value, pays attention on value of whole variables used which are combined based on equation of dempster's rule of combination, so that there will be produced values from the calculation which is more varied and more accurate. The writer concludes that dempster-shafer is one of good uncertainty value completion ways in determining percentage of belief value.

System will not find the kind of disease suffered by the user's dog if the user answers "no" in each question. It can be seen in Fig. 11.

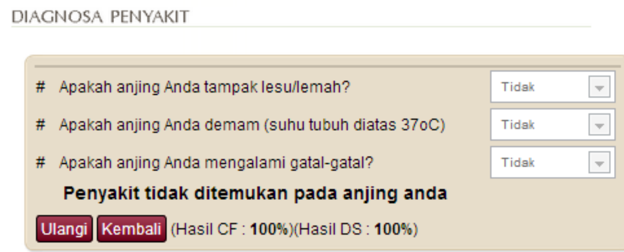

Fig. 11 No disease found

4. Conclusions

There is comparative relevant in Certainty Factor and Dempster-Shafer method in this paper. Certainty factor method has simpler calculation than dempster-shafer method. Dempster-Shafer method is better than Certainty Factor because in determining the results of the belief percentage consider the value of all variables used in combination by equation Dempster's Rule of Combination resulting calculation values are more varied and more accurate. Based on this data, the writer concludes that dempster-shafer is one of good uncertainty value completion ways in determining percentage of belief value.

The accuracy of the analysis of each method was tested by assessing the results of each analysis method based on the given user enter. The results of the analysis are correct when judged from the point of view of experts. Used 10 cases will be assessed and tested to the experts, namely Drh. Ary as a veterinarian.

Table 6: Accuracy of Result

Case	Percentage of Accuracy Using Certainty Factor (%)	Percentage of Accuracy Using Dempster-Shafer(%)
1	80	85
2	65	70
3	70	75
4	70	70
5	90	90
6	75	80
7	70	65
8	70	75
9	65	75
10	80	85
avg	73	76

Based on the value of the accuracy of the above could be said that the analysis method is good enough.

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