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Comparison of Accuracy Level of Certainty Factor Method and Bayes Theorem on Cattle Disease

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Abstract

This study aims to address the challenges of livestock disease diagnosis in Okaba district, Meraoke, Papua. A total of 2 paramedics or veterinarians and 1 assistant is not sufficient because of the long distances that the medics have to travel, traveling from all areas of Okaba District to its interior. Keepers can only utilize their basic skills for temporary care. The researcher's process included interviews with experts covering the disease, its symptoms and prevention, then analyzed with the provision of utilizing certainty factors and Bayes' theorem to increase the accuracy and veracity of the findings. In this scenario, the data is used as a reference point for analysis in the web-based expert system. The results obtained when processing the problem estimation are disease information, symptom information, and treatment. The reference in the application and analysis shows that the Certainty Factor method is superior in providing consistent accuracy, with a percentage reaching 98.79% in the case of worms, while the Bayes Theorem method shows lower accuracy, around 73%. The comparison indicates that Certainty Factor is more suitable in high uncertainty environments, while Bayes' Theorem is more effective when sufficient probabilistic data is available. Future suggestions can expand the scope by testing other methods such as Machine Learning or Artificial Neural Networks to increase the accuracy of the diagnosis percentage. In addition, more extensive trials on different types of livestock and different environmental conditions will help in developing a more flexible and robust system.

Keywords: Bayes' theorem; Certainty factor; Cow diagnosis; Expert system

Introduction

Papua & West Papua are grand provinces rich in natural resources and large domesticated capacity. Based on data from the West Papua Health and Livestock Service Master Plan (2017), in West Papua there is ±4,244,275 ha of land capable of producing animal feed and agro/crop waste. The availability of livestock resources is a good opportunity for livestock in West Papua province [1]. Case study [2] deals with the problem of uncertainty in making decisions to provide appropriate treatment based on the symptoms suffered by cows and the type of disease they have. To overcome this problem, the developer created an expert system with the method of Surety Factor in diagnosing diseases in cattle. However, the development still uses manual calculations without using the system to get more precise accuracy. Research by Susanto [3] is the application of a knowledge-based system with specific factors and disease transition chains in goats. Efforts should be made to overcome the problems associated with goat rearing. One of them is animal health by knowing how to combat goat diseases. If the treatment of the disease is not maximized, the performance of the goat will decrease. Further researchers [4] addressed selected knowledge representation and reasoning issues: modeling and mental workload assessment. An invention by ginting [5] It is mentioned that knowledge-based systems are generally an application of the experience of expert knowledge systems to computers. So it can solve problems like professional experts. Experts believe that the cause of the increase in the number of people with autism is the lack of experience of parents, specialists in diagnosing and promoting the causes of autism. The shortage of doctors can be overcome in creating a knowledge-based system. Expert systems only represent specialists when diagnosing early signs of autism in children using the uncertainty of the certainty factor. In a scenario by [6], the issue raised in this journal is Indonesia's dependence on imported milk and beef from abroad due to low domestic cattle production capacity. Factors affecting this low production are cattle diseases such as anthrax, bovine snoring disease, pneumonia, brucellosis, and diseases caused by parasitic worms. In addition, cattle farmers often lack knowledge about animal husbandry techniques and cattle health, making it difficult to diagnose diseases correctly. However, researchers have not compared the accuracy results with other tools. Experienced [7] farmers lack information on the types of infectious diseases that often affect cattle, their signs or symptoms, and prevention solutions. This leads to deaths in livestock and huge losses. The following researchers addressed one of the data classification problems.

The next authors [8] found that in modern times it is still difficult to find an expert, especially with the distance that farmers have to travel to find an expert. Based on the existing problems, the result is that cattle that do not receive immediate help will experience symptoms that can even lead to death. Research that has been done [9] With the delay in handling due to limited problems, research was conducted to analyze some of the knowledge base system algorithms to identify the disease of merchant chickens through the recognition mechanism to an expert in the field of chicken farming. The issue encountered in this study revolves around the challenge faced by the general populace in diagnosing bone cancer. Additionally, there exists a hurdle in effectively utilizing the expertise-based knowledge repository. As a solution, the approach of advancing the concept of Artificial Intelligence (AI) has been undertaken through development efforts. A challenge faced by studies [10], [11] is that communities, especially cattle farmers, still lack knowledge about cattle diseases. Farmers, especially in remote areas, may not have easy access to veterinary services or the knowledge required to diagnose diseases appropriately.

A problem facing sorong district today is that people, especially farmers, still have difficulty identifying frequent livestock diseases, worms, which cause severe diarrhea, are a major killer of livestock, according to animal health officers at the local Food, Livestock and Animal Health Office. As a result, the cattle look emaciated, and their immune systems decline until they eventually die. In response to the recently reported deaths of several cattle in Okaba district, Meraoke, due to foot and mouth disease (FMD), paramedics in the Meraoke region need additional premedical teams to cover a very large area. Using Certainty Factor and Bayes Theorem is a very important thing to do because, it can be seen from the comparison results later. This method is very useful and helps in producing a good and precise percentage.

Therefore, a safe and accessible expert system for diagnosing cattle diseases is needed for cattle breeders in Okaba District in Meraoke. This research examines the knowledge base system in diagnosing cattle diseases using the certainty factor method and Bayes hypothesis. This stage is used to ensure the certainty of the calculation of the results of the diagnosis of cattle complications in the two rules, compare the percentage of calculations to determine the best method and present the diagnosis results through a web-based system and is feasible to be used as a cattle disease diagnosis application for rural communities in the Meraoke region through a cattle disease expert system.

So the author tries to compare the accuracy results of the two methods, to get which method has a high percentage of accuracy in this case too, the author compares through the system so that the accuracy oained is clearer. Based on some exposure of the problems between researchers 1 to 12 still have some shortcomings that must be developed in this study by displaying the results of the image and the percentage of accuracy with the amount of uncertainty between 80% to 98% certainty factor and probability between 70% to 90% with bayes theorem.

Expert System

A knowledge base is an application that uses a computer to solve problems as an expert by using knowledge, evidence, and reasoning techniques. Specialist knowledge also forms a basis for interpretability of the expert system's belief rule base [12] [13]. During diagnosis, the patient's first step is to answer the system's questions as an expert to determine the Indications of the ailment are assessed, followed by responding to inquiries. Subsequently, the system will present the corresponding diagnostic score [14]. Computer-based deduction is employed utilizing the Certainty Factor approach [15]. The inception of expert systems occurred within In the mid-1960s, field of AI saw its initial developments. One notable example of such a system General Purposed Problems solvers (GPS), a pioneering creation of Newel & Simon [16]. Can you rewrite this passage in simpler language. AI encompasses intelligent systems, computer programs that are integrated into the field of computer science. The purpose of AI is to make something intelligent in terms of understanding through computer programs that are shown with something, concepts and methods of symbolic inference or reasoning carried out by computers and are also concerned with how knowledge is used to make a conclusion that will be represented in a machine [17] [18].

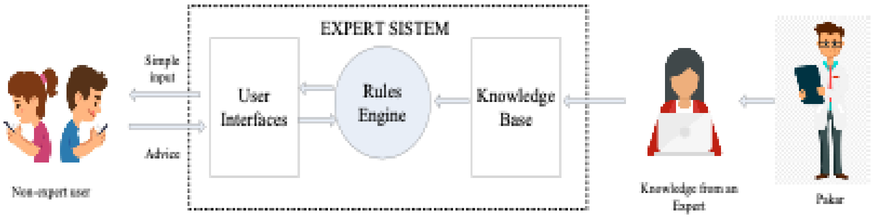

Figure 1. Inference Engine Scenario

Figure 1 which is listed, shows the indication process that is tested with two techniques, namely certainty factor (CF) and bayes theorem () to diagnose the user will be directed to a simple input display on the user interfaces, input that is processed through interfaces and will enter the rules engine and then processed. After that, the knowledge base is oained through the results of an expert and field studies which later the data knowledge is entered into the knowledge base by knowledge from an expert. the final part of the rules engine will provide the results of the input that has been given by the user interfaces.

Method

In the research stage carried out, it covers the process from problem identification to the results of the percentage comparison on the highest accuracy in graphical form with the two methods used, namely Bayes theorem and certainty factor. According to [19] -he framework for research makes it easier on researchers in conducting studies because it will be the basis for conducting studies, as can be seen in the following **Figure 2**.

Figure 2. Research Stages [20]

This **Figure 2** illustrates a five-step process in a structured flow, detailing the phases involved in a project or research methodology [21], [22]:

1. STEP 1: Identification of Problems
   The first step involves identifying the core issues or problems that need to be addressed. This sets the foundation for the entire process by determining the objective and focus of the research or system development.
2. STEP 2: Methods of Data Collection, Observation, and Literature Study
   In this phase, various methods for gathering data are employed, such as direct observation, surveys, or reviewing relevant literature. This step is crucial for understanding the problem in-depth and collecting information that will support further analysis.
3. STEP 3: Comparison of Method Accuracy Levels
   Once data is collected, different methods are analysed and compared based on their accuracy or effectiveness. The goal here is to determine which methods provide the most reliable or accurate results in solving the identified problem.
4. STEP 4: Output Results with Web-Based System
   The fourth step involves presenting the results or solutions through a web-based system. This allows for easier access and implementation of the outcomes derived from the previous analysis, typically utilizing a digital platform for better efficiency.
5. STEP 5: Percentage Comparison Chart
   The final step visualizes the data by presenting a percentage-based comparison chart. This helps in comparing different methods, outcomes, or results, making the information easier to interpret and draw conclusions from.

A. Certainty Factor (CF)

The expert systems are computers resources or informational support systems of expertise, it can also provide instant expert-quality countermeasures to problems in a particular area [23] [24] [25]. The theory Certainty Factor (CF) was proposed by Shortlife and Buchanan in 1975 to accommodate the uncertainty of an expert's inexact reasoning [26]. A certainty factor is a form that shows a fact is true or not true, in the form of a matrix when diagnosing the substance of uncertainty. There are many methods for building expert app to facilitate resolving existing problem. Knowledge-based systems are (AI) program that incorporates knowledge (Knowledge Base) by an inference engine [27]. AI (artificial intelligence) is a branch that provides a special extension of specialized knowledge to solve human expert problems. A human expert is an expert in a particular field of science as well as a doctor, as a specialist who can identify a patient [28] [29].

$$\mathrm{CF}\ (h, \mathrm{e}) = MB\ (h, \mathrm{e}) - MD\ (h, \mathrm{e}) \tag{1}$$

Where,

$CF\ (h, e)$: Variable clarity hypothesa h is infected with indication (evidenc) e.

$MB(h, e)$: Confidence level, is confiden level of rule h when affected by evidence (0) e.

$MD(H, e)$: Degree of uncertainty (level of skepticism), specifically the extent of skepticism associated with rule h, is influenced by the presence of indications e.

h : Hypotheses or conclusions are generated, resulting in binary outcomes of either 1 or 0.

e :Evidence or occurrences, often in the form of symptoms, are considered.

The formula of what premise is involved assumes that there is no particular factor that causes the type that any manifestation can cause the disease. The combination of belief factors used to analyze infections, namely:

a. *Certainty Factor* as a premise/symptom only procedure (assumption only rule):

$$\mathrm{CF\ (H|E)paralel} = \mathrm{CF\ (E)user} * \mathrm{CF\ (E)experts} \tag{2}$$

b. Thus, it is speculated that if a provision aims to remain comparable (the rule concludes similarly) or vice versa, more than one manifestation is determined by the current situation:

$$\begin{gathered}\mathrm{CF\ (H\ |\ CF1, CF2)} \\ combine = \mathrm{CF1} + \mathrm{CF2} \times (1 - \mathrm{CF1})\end{gathered} \tag{3}$$

Where,

$CF\ (H|E)_{paralel}$: Is value of the certainty factor the parallel hypothesis H if given a symptom or evidence E.

$CF\ (E)_{user}$: Value of the certainty factors by symptoms or evidence E when provided by the user.

$CF\ (E)_{experts}$: Value of the certainty factors by symptom and evidence E when provided by experts

$CF\ (H|CF_1, CF_2)$ combine: is the certainty factor of the combination of symptoms or evidence E by hypothesis H, While the requirements for calculating the infection rate use the formula below:

$$CFpresentations = CFcombine \ \mathrm{x100\%} \tag{4}$$

The calculation below is a combination of at least two principles with different arguments, but still with the same formula as below formulas:

$$Rule1: CF(h, e_1) = CF_1 = C(e_1)\ x\ CF(rule1) \tag{5}$$

$$Rule2: CF(h, e_2) = CF_2 = C(e_2)\ x\ CF(rule2) \tag{6}$$

$$CFcombinasi\ [CF_1, CF_2] = CF_1 + CF_2(1 - CF_1) \tag{7}$$

Below is **Figure 3** which is the flowchat of the CF method:

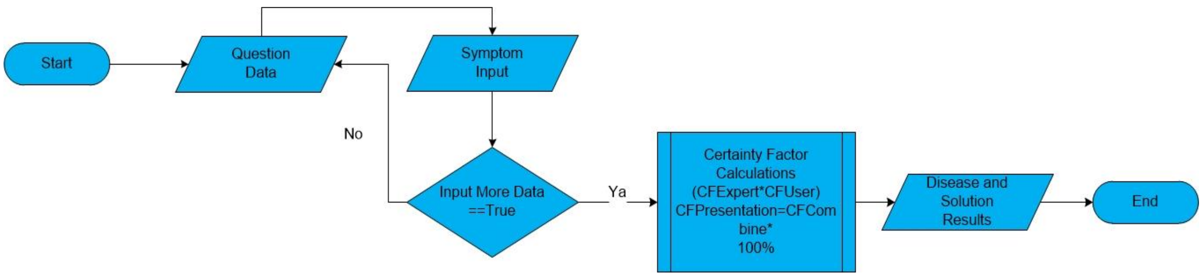

Figure 3. Certainty Factor Flowchart

B. Theorem Bayes (BT)

Bayes' Theorem is a way to resolve uncertain data by using a formula called Bayes and an algorithm built on the basis that each pair of properties is used to categorize something that stands alone [30] [31]. Naive Bayes based on Bayes theorem. This theorem is proposed by a British presbyterian pastor called Thomas Bayes (1763) and later refined by laplace. The Bayes' Theorem algorithm is able to generate parameter estimates by combining information from pre-existing samples [32]. Algorithm Bayes Hypothesis can be expressed as Equations [33]:

$$P(H_k|E) = \frac{P\,(E|H_k)\ P(H_k)}{\sum k\ =\ 1, n\, P(E|H_k)\, P(H_k)} \quad (8)$$

Where,
$P(H_k \mid E)$: Probability and hypothesis H_k given evidences E.
$P(E \mid H_k)$: Probability of evinden E occurring when hypothesa H $_k$ correct
$P(H_k)$: Probability hypothesis H $_k$ does not have to maintain any evidence
n : There are many hypothetical possibilities
k : 1,2,…n
Techniques bayesian hypothesis or bayesian probability which is a way to overcome the weakness of information includes the bayesian formula, which is as follows:

$$P\,(H|E, e\,) = \frac{P\,(H|E)\ P\,(e|E, H)}{P(e\,|E)} \quad (9)$$

Where,
e : Longest proof
E : New evidence
$P(H|E,e)$: The likelihood that hypothesis H holds true while taking into account evidence E prior to evidence e.
$P(e|E,H)$: Probability of a connection between e or E in the event that hypothesis H is valid.
$P(e|E)$: Probability of the relationship between e or E does not have to look at any hypothesis.
$P(H|E)$: Chance of the probability increasing evidence E if hypothesis H is known.

Below is **Figure 4** which is a flow chart of the BT method.

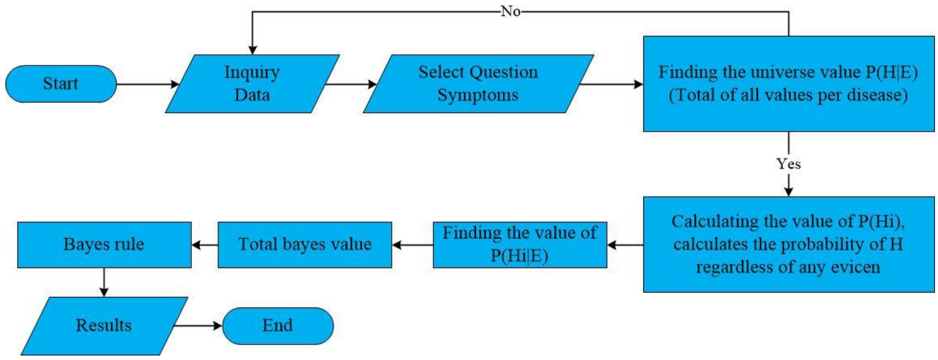

Figure 4. Flowchart of Bayes' Theorem

Results and Discussion

From interviewing three experts, including two veterinarians and a paramedic, to analyzing the expert system, this was done through data collection and reviewing system requirements. Below is information about cattle diseases that the author collected during interviews with doctors, in the form of a data of symptoms, diseases, solutions and descriptions and disease rules. Below is **Table 1** Information Data of 9 diseases and 24 symptoms used as real data by researchers oained from experts in sorong district in 2023.

Table 1. Disease and Symptom Information

Diseases	Symptoms
PY01. Worms	GPY01. Skinny GPY02. Standing hair GPY03. Diarrhea GPY04. Lack of appetite
PY02. Myasis	GPY05. Wounds on the body GPY06. The presence of flies in the wound area GPY07. The presence of maggots in the wound area
PY03. Bloody Stool	GPY03. Diarrhea

Diseases	Symptoms
	GPY08. Liquid stools tend to be mushy GPY09. Feces mixed with blood
PY04. Coryza	GPY10. Nasal and eye discharge and unpleasant odor GPY11. Swelling of the eyes and nose GPY12. Red eyelids GPY13. Closed eyes GPY14. Difficulty breathing
PY05. 3-day fever	GPY04. Lack of appetite GPY15. Fever GPY16. Convulsions GPY17. Difficulty standing or limping
PY06. Salmonellosis	GPY03. Diarrhea GPY18. Weakness GPY19. Reduced milk production
PY07. Miscarriage/ Brucelosis	GPY20. 6 months pregnant, brown discharge from vaginal labia GPY21. Fetus does not come out on time
PY08. Nail Rot	GPY17. Difficulty standing or limping GPY22. Yellow discharge and unpleasant odor in the affected nail area
PY09. Scabies	GPY23. Nervousness in the body GPY24. Berudis in the peripheral area

Interpretation of certainty factor is combining belief and unbelief into one number. In certainty theory, reference information is presented as a level of confidence. **Table 4** is the uncertainty values provided by experts, which serve as a benchmark to confirm the accuracy of the diagnosed medical condition [34].

Table 2. Interpretation of Certainty Factor

No.	Term Certaint	CF Value
1	No	0
2	Enough	0,4
3	Sure	0,8
4	Very Sure	1

A. Certainty Factor

After handling the case, then calculation method as a confidence factor for the indication is in the section below.

Table 3. Noticeable Symptoms

Symptom Code	Symptom	CFExpert	CFUser
GPY01	Skinny	0,8	1
GPY02	Standing Hair	0,4	0,4
GPY03	Diarrhea	0,8	0,8
GPY04	Lack of appetite	1	0,8

a) Perform calculations by finding the CF symptom value by the Equation 2

$CF\ (H|E)_{parallel} = CF(E)_{user} \times CF(E)_{experts}$
$gpy01 = 0.8 \times 1 = 0.8$
$gpy02 = 0.4 \times 0.4 = 0.16$
$gpy03 = 0.8 \times 0.8 = 0.64$
$gpy04 = 0.8 \times 1 = 0.8$

b) Next, calculate using Equation 3 because it exceeds one symptom that is summed up.

$CF(H|CF_1, CF_2)combine = CF_1 + CF_2 \times (1 - CF_1)$
$CFcombine\ (gpy\ 01, 02)$
$= CF_1 + CF_2 \times (1 - CF_1)$ [21]
$= 0.8 + 0.16\ (1 - 0.8)$
$= 0.832$
$CFcombine\ (gpy01, 02, 03)$
$= 0.832 + 0.64(1 - 0.832)$
$= 0.93952$
$CFcombine\ (gpy\ 01{,}02{,}03{,}04)$

$= 0.93952 + 0.8(1 - 0.93952)$
$= 0.987904$
Next calculate the percent by Equation 4
$CFpresentations = 0.987904 \times 100$
$= 98.7904\%$

From the discussion above, the conclusion is that if we input GPY001, GPY002, GPY003, GPY004, then the percentage of the sign calculation result is 98.7904%, which is worm. The result of diagnosis through is shown in **Figure 5**.

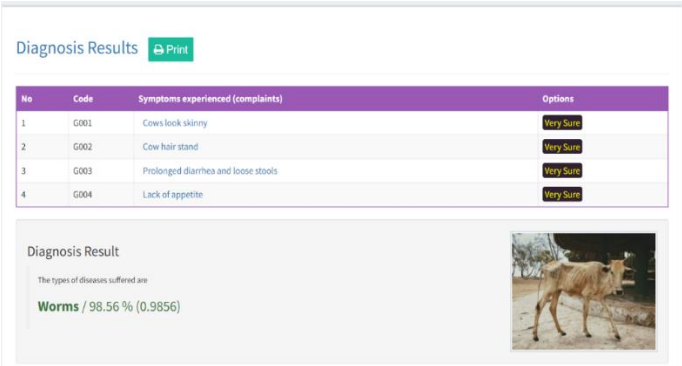

Figure 5. Percentage Result Graph

Diagnosis through the system with CF in **Figure 5** has a slight difference with manual calculation, however, this result is very similar to the manual calculations.

B. Bayes' Theorem

Given the following questions, the bayes technique is used to calculate Indication complication with the bayes theorem hypothesis formula:

GPY01: Skinny
GPY02 : Standing Feather
GPY03 : Diarrhea
GPY04 : Lack of Appetite.

a. The first steps is to calculate probability values case above using the Equation 8

$$disease\ probability\ formula = \frac{1}{9} = 0{,}11$$

Then calculate by knowing the probability value of the first disease-causing indication:

$$PY(GPY) = \frac{number\ of\ possibilities}{number\ of\ possible\ diseases\ due\ to\ symptoms}$$

$$GPY01 = \frac{1}{1} = 1$$

$$GPY02 = \frac{1}{1} = 1$$

$$GPY03 = \frac{1}{3} = 0{,}33$$

$$4 = \frac{1}{2} = 0{,}5$$

b. Calculate the bayes sum of disease one using the Equation 9

$\boldsymbol{H0i, i = H(GPY0i \mid PYi)}$, where iii represents the subscript of GPY and PY.

$\boldsymbol{Pi = H(PYi)}$, where iii represents the subscript of PY

$$\mathrm{H(PY01|GPY01)} = \frac{\mathrm{H01{,}01 \cdot P01}}{\mathrm{H01{,}01 \cdot P01 + H01{,}03 \cdot P02 + H01{,}05 \cdot P05 + H01{,}06 \cdot P06}}$$

$$= \frac{[1 \times 0.11]}{[(1 \times 0.11) + (0 \times 0.11) + (0 \times 0.11) + (0 \times 0.11)]}$$

$$= \frac{0.11}{0.11 + 0 + 0 + 0} = \frac{0.11}{0.11} = 1$$

$$H(PY01|GPY02) = \frac{H02{,}01 \cdot P01}{H02{,}01 \cdot P01 + H02{,}03 \cdot P03 + H02{,}05 \cdot P05 + H02{,}06 \cdot P06}$$

$$= \frac{[1 \times 0.11]}{[(1 \times 0.11) + (0 \times 0.11) + (0 \times 0.11) + (0 \times 0.11)]}$$

$$= \frac{0.11}{0.11 + 0 + 0 + 0} = \frac{0.11}{0.11} = 1$$

$$H(PY01|GPY03) = \frac{H03{,}01 \cdot P01}{H03{,}01 \cdot P01 + H03{,}03 \cdot P03 + H03{,}05 \cdot P05 + H03{,}06 \cdot P06}$$

$$= \frac{[0.33 \times 0.11]}{[(0.33 \times 0.11) + (0.33 \times 0.11) + (0 \times 0.11) + (0.33 \times 0.11)]}$$

$$= \frac{0.0363}{0.0363 + 0.0363 + 0 + 0.0363} = \frac{0.0363}{0.1089} = 0{,}33$$

$$H(PY01|GPY04) = \frac{H04{,}01 \cdot P01}{H04{,}01 \cdot P01 + H04{,}03 \cdot P03 + H04{,}05 \cdot P05 + H04{,}06 \cdot P06}$$

$$= \frac{[0.5 \times 0.11]}{[(0.5 \times 0.11) + (0 \times 0.11) + (0.5 \times 0.11) + (0 \times 0.11)]}$$

$$= \frac{0.055}{0.055 + 0 + 0.055 + 0} = \frac{0.055}{0.11} = 0{,}5$$

Number of bayes calculations PY01 = 1 + 1 + 0,33 + 0,5 = 2,83 formula to (9)

c. Find the percentage of predicted value using the Equation 9

$$(PY01) = \frac{total\ bayes\ PY001}{total\ hasil} * 100\%$$

$$= \frac{2{,}83}{3{,}83} \times 100\% = 73\%$$

The value of 3.99 is oained from the total result = total bayes $PY01 + PY03 + PY05 + PY06$. The total result $= 2.83 + 0.33 + 0.5 + 0.33 = 3.83$. Using the same Equation 8 and 9, the result can be seen in **Figure 6** with detection through a system.

Selected Symptoms

No	Symptom Name
1	Cattle look thin
2	Cow hair stand
3	Prolonged diarrhea and loose stools
4	Lack of Appetite

Analysis Result

Disease Name	Disease Weight	Selected Symptoms	Rule Weight	Multiplication	Results
Worms	1	Cattle look thin	1	0.32	0.7273
		Cow hair stand	0.4		
		Prolonged diarrhea and loose stools	0.8		
		Lack of Appetite	1		
Discharge of Blood	0.2	Prolonged diarrhea and loose stools	0.2	0.04	0.0909
3-day fever	0.2	Lack of Appetite	0.2	0.04	0.0909
Salmonellosis	0.2	Prolonged diarrhea and loose stools	0.2	0.04	0.0909
Total				0.44	

Largest Results Earned by Disease = **Worms** with Value = **72.73 %**

Figure 6. Bayes' Theorem Diagnosis Percentage

Based on the detection results using , the difference in percentage oained through the system and manual calculation is not much different because basically the method only uses probability.

C. Percentage Results Comparison Calculations

Based on the accuracy rate results through data in the form of graphs, the resulting disease with the highest value is certainty factor (CF) 98.7904 and bayes theorem () with a value of 73.91304348 as shown in **Figure 7** below.

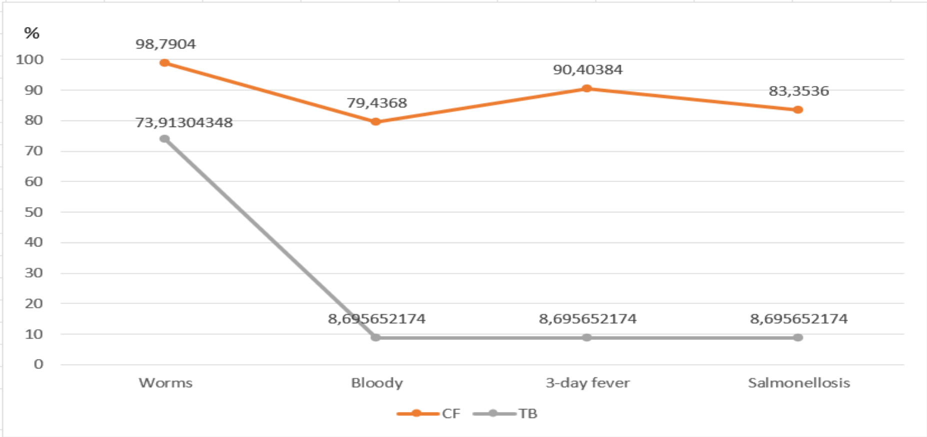

Figure 7. Percentage Data In Graphical Form

The graph above shows the comparison between two variables, CF (orange color) and BT (gray color), in percentage against four types of diseases: Worms, Bloody Diarrhea, 3-day Fever, and Salmonellosis. Shown in **Table 4**.

Table 4. Graphical Percentage

Disease Outcome	Result Explanation
Worms	CF has the highest percentage at 98.79%. BT is lower than CF, standing at 73.91%.
Bloody Diarrhea	CF saw a sharp drop to 79.44%.
	BT also dropped drastically to 8.70%, showing a significant difference between CF and BT.
3-day fever	CF rises again to 90.40%, showing a considerable increase
	BT remained at a very low 8.70%, the same as in Bloody Diarrhea
Salmonellosis	CF decreased slightly to 83.35%
	BT remained constant at 8.70%, no change since the Bloody Diarrhea category

It was concluded that CF overall had a much higher percentage than BT for all disease categories. BT had a drastic drop and remained low after the Worms category, while CF showed fluctuations but remained above 79% for each category. This graph gives an idea of the effectiveness or variable prevalence of CF over BT in the four diseases mentioned.

D. Comparison of Certainty Factor and Teorma Bayes Methods

So the evaluation of the confidence factor and bayes' theorem, a conclusion is drawn according to the scenario, which compares the system test results in **Table 5**

Table 5. Comparison of Testing Process Results

No.	Name	Symptom	Diagnostic Result		
			Name of Disease	*Certainty Factor (%)*	*Bayes' Theorem (%)*
1	Case One	GPY01, GPY03, GPY04	Worms	95,33	68,09
2	Case Two	GPY06, GPY07, GPY10	Myasis	87,04	50
3	Case Three	GPY03, GPY18,	Salmonellosis	81,28	61,54

No.	Name	Symptom	Diagnostic Result		
			Name of Disease	*Certainty Factor (%)*	*Bayes' Theorem (%)*
		GPY17			
4	Case Four	GPY22, GPY23, GPY24	Scabies	87,04	80
5	Case Five	GPY04, GPY15, GPY17	3-day fever	87,27	81,63
6	Case Six	GPY01, GPY11, GPY12	Coryza	72,96	50
7	Case Seven	GPY01, GPY04, GPY06	Worms	87,04	52,63
8	Case Eight	GPY06, GPY07, GPY08	Myasis	87,04	80
9	Case Nine	GPY07, GPY13, GPY15	Myasis	64	44,44
10	Case Ten	GPY15, GPY16, GPY17	3-day fever	81,28	66,67

On the basis of comparative findings from the aforementioned system test, we can conclude that certainty factors is very appropriate for performing calculations related to diagnosing problem implications. This is primarily due to the methodology's reliance on probability comparisons to acquire evidence. In contrast, the certainty factor approach relies solely on a proportion of the existing uncertainty.

E. Pros and Cons of the 10 Detected Cases

Advantages and Disadvantages of Comparison Results of Certainty Factor (CF) and Bayes Theorem on 10 Cases:

a) Pros: (CF): Accurate and consistent: CF often gives higher and consistent results, especially in cases like Worms (Case One: 95.33% vs. Bayes 68.09%). Easy to apply: It does not require a lot of statistical data, making it suitable for use in expert systems based on expert knowledge. Bayes' Theorem: Precision with enough data: Bayes gives better results when there is strong probabilistic data, such as in Scabies (Case Four: 80%). Considers historical data: Bayes uses previous information to produce a more scalable diagnosis.

b) Disadvantages: (CF): Does not consider historical evidence: CF does not use probabilities or empirical data, so it can give less precise results without strong supporting data. Subjective: CF results depend on expert judgment, so they can differ depending on who is providing the rule. Bayes' Theorem: Need valid data: If there is not enough probabilistic data, the results can be less accurate, such as in Coryza (Case Six: Bayes 50%). Difficult to apply with limited data: Bayes is less than optimal in environments with little or no historical data.

Conclusion Certainty Factor is better to use when historical data is limited and the system relies on expert knowledge. Bayes' Theorem is more suitable when there is enough probabilistic data to produce more precise results.

F. Discussions

Comparing with the current method, in evaluating how the proposed method works, the expert system with two methods CF and BT or other to get the accuracy rate of presentation in this study CF 98.7904%, BT 73.9%. Previous researchers stated that, the CF method in an expert system can diagnose cattle diseases, by utilizing symptom data from users and expert judgment [2], [3] but other researchers said that by combining both CF and FC search methods, the resulting information can find the types of diseases and recommend effective treatment for these diseases with a high level of certainty, said again by other researchers [4] The expert system developed in this study functions as a decision-making tool that mimics the problem-solving ability of an expert in the context of measuring mental workload. Another researcher [5] said that the ability of the CF and methods to measure the level of confidence in the diagnosis based on the symptoms that appear, allows the system to provide more accurate results, with an accuracy rate above 90%. That said, expert systems also have very important uses in the diagnosis and decision-making process, especially in the context of diagnosing autism in children. Researcher [6] stated that also developing an expert system to diagnose cattle diseases will be able to utilize the knowledge of veterinarians to analyze symptoms and determine the weight of each symptom. The method used works by starting from known facts (symptoms) and gradually applying existing rules to reach a relevant conclusion or diagnosis [7]. Researcher [8] stated an expert system for diagnosing diseases in bovine animals, especially in the context of improving the efficiency and accuracy of diagnosis. The CBR method functions by relying on experience from previous cases to solve new problems [9], [10] said the use of the CF method in diagnosing is very important in the development of expert systems to diagnose diseases.

Our study analysis shows that previous researchers did not test more cases than those listed in Table 4, 5 and also previous researchers did not compare through the system and through the results of analysis with graphs such as Figures 5, 6 and 7 can be checked at the top. on this occasion the research was conducted in Okaba District Meraoke Papua and there was no similar research and similar cases owned by previous researchers, the data owned was data provided by veterinarians who are currently still active in handling large animals such as cows and goats.

According to these discussions, we know that the research still has a few shortcomings in that it makes the computation process manually which makes the margin inadequate, but in the future other methods can be used such as fuzzy logic, deep neural network (DNN), Depth First Search, Breadth First Search, Best First Search or it can be with using case-based reasoning narrow the counts searching techniques.

Conclusion

This study compared two livestock disease diagnosis methods, namely Certainty Factor (CF) and Bayes' Theorem (BT), applied to nine types of diseases and 24 symptoms of livestock in Sorong District in 2023. Tests were conducted to compare the accuracy of disease diagnosis through both methods. From the results of calculating using CF, it was found that the confidence level of worming diagnosis was 98.79%, which indicates that CF provides highly accurate results. In contrast, calculations using the TB method yielded a confidence level of 73.91%, which is lower than CF. Graphical analysis showed that CF tended to give higher and more stable results than TB for most of the diseases tested. Based on the results obtained, it is recommended that future research use a comparison of other more sophisticated methods such as fuzzy logic, deep neural network (DNN), and search algorithms such as Depth First Search, Breadth First Search, or Best First Search to improve the percentage accuracy of cattle disease diagnosis.

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References

[1] T. W. Widayati and I. Sumpe, "Pengaruh Umur Jual Sapi Dan Jumlah Kepemilikan Induk Sapi Terhadap Penerimaan Usaha Sapi Potong Di Papua Barat," *Pros. Semin. Teknol. dan Agribisnis Peternak. VII-Webinar Prospek Peternak. di Era Norm. Baru Pasca Pandemi COVID-19*, pp. 254–260, 2020.

[2] S. Maryana and D. Suhartini, "Implementasi Certainty Factor Untuk Diagnosa Penyakit Sapi," *Chain J. Comput. Technol. Comput. Eng. Informatics*, vol. 1, no. 1, pp. 14–20, 2022, doi: 10.58602/chain.v1i1.5.

[3] D. Susanto, A. Fadlil, and A. Yudhana, "Application of the Certainty Factor and Forward Chaining Methods to a Goat Disease Expert System," *Khazanah Inform. J. Ilmu Komput. dan Inform.*, vol. 6, no. 2, 2020, doi: 10.23917/khif.v6i2.10867.

[4] L. Rizzo and L. Longo, "An empirical evaluation of the inferential capacity of defeasible argumentation, non-monotonic fuzzy reasoning and expert systems," *Expert Syst. Appl.*, vol. 147, 2020, doi: 10.1016/j.eswa.2020.113220.

[5] R. Ginting, M. Zarlis, and R. Rosnelly, "Analisis Perbandingan Metode Certainty Factor dan Teorema Bayes untuk Mendiagnosa Penyakit Autis Pada Anak," *J. MEDIA Inform. BUDIDARMA*, vol. 5, no. 2, p. 583, Feb. 2021, doi: 10.30865/mib.v5i2.2930.

[6] P. E. Wardani, Y. Siagian, and M. Ihsan, "Sistem Pakar Untuk Diagnosa Penyakit Sapi Menggunakan Metode Promethee," *OKTAL J. Ilmu Komput. dan Sci.*, vol. 2, no. 2, pp. 419–428, 2023, doi: 10.47065/bits.v4i2.2197.

[7] R. Hendri, Y. Safitri, and D. A. Prayudha, "Implementasi Metode Forward Chaining dalam Sistem Pakar Untuk Mendeteksi Penyakit Ternak," *J. Teknol. dan Inform.*, vol. 4, no. 1, pp. 161–167, 2024, doi: 10.57084/jeda.v5i1.1602.

[8] T. E. Hutahaean and S. Aliyah, "Penerapan Sistem Pakar Metode Forward Chaining Dan Case Based Reasoning Dalam Mendiagnosa Penyakit Hewan Sapi Berbasis Web Pd. Rumah Potong Hewan," *J. Widya*, vol. 5, no. 2, pp. 2807–5528, 2024, doi: 10.54593/awl.v5i2.286.

[9] A. Afandi and D. M. Efendi, "Implementasi Sistem Pakar Metode Forward Chaining dan Certainty Factor pada Ayam Pedaging," *Techné J. Ilm. Elektrotek.*, vol. 19, no. 02, pp. 101–112, 2020, doi:

10.31358/techne.v19i02.234.

[10] F. R. B. Putra, A. Fadlil, and R. Umar, "Analisis Metode Forward Chaining Pada Sistem Pakar Diagnosa Penyakit Hewan Sapi Berbasis Android," *J. Sains Komput. Inform. (J-SAKTI*, vol. 5, no. 2, pp. 1034–1044, 2021, doi: 10.30645/j-sakti.v5i2.398.

[11] D. D. Prayogo, Agustina Srirahayu, and I. Oktaviani, "Sistem Pakar Dengan Metode Forward Chaining Dalam Menentukan Penyakit Pada Sapi Berbasis Web," *Jutisi J. Ilm. Tek. Inform. dan Sist. Inf.*, vol. 4, no. 1, pp. 98–106, 2023, doi: 10.35889/jutisi.v13i2.2137.

[12] S. Chatterjee, D. Dey, S. Munshi, and S. Gorai, "Dermatological expert system implementing the ABCD rule of dermoscopy for skin disease identification," *Expert Syst. Appl.*, vol. 167, p. 114204, 2021, doi: 10.1016/j.eswa.2020.114204.

[13] A. Satria, A. Naufal Yulianra, M. Az Zahrah, and M. S. Anggreainy, "Application of the Certainty Factor and Forward Chaining Methods to a Cat Disease Expert System," in *2022 3rd International Conference on Artificial Intelligence and Data Sciences (AiDAS)*, 2022, pp. 83–88. doi: 10.1109/AiDAS56890.2022.9918803.

[14] S. de, P. Goswami, N. Faujdar, and G. Singh, "Gynaecological Disease Diagnosis Expert System (GDDES) Based on Machine Learning Algorithm and Natural Language Processing," *IEEE Access*, vol. 12, pp. 84204–84215, 2024, doi: 10.1109/ACCESS.2024.3406162.

[15] A. R. Al Ali, R. D. Pradani, D. M. Nor, F. R. Saputri, K. N. Ramli, and M. N. Mahmud, "Expert System Development Diagnosis of Rabbit Disease Using Case-Based Reasoning Method and Certainty Factor Method," in *2024 International Conference on Future Technologies for Smart Society (ICFTSS)*, 2024, pp. 157–160. doi: 10.1109/ICFTSS61109.2024.10691332.

[16] M. R. Hanafi *et al.*, "Analisis Perancangan Sistem Pakar Pendeteksi Kerusakan Hardware Pada Komputer Berbasis Web Dengan Metode Naive Bayes," vol. 17, pp. 1190–1206, 2023, doi: https://doi.org/10.46576/wdw.v17i3.3575.

[17] S. García Galán *et al.*, "Expert system-based application for fatal ventricular arrhythmia risk level estimation based on QT-Interval prolongation," *Expert Syst. Appl.*, vol. 255, p. 124381, 2024, doi: 10.1016/j.eswa.2024.124381.

[18] A. Voutama, A. Rizala, and R. Saputra, "Penerapan Forward Chaining Pada Sistem Pakar Pengendalian Internal Bank Pemberian Kredit Pemilikan Rumah," *Ilk. J. Ilm.*, vol. 15, no. 1, pp. 193–200, 2023, doi: 10.33096/ilkom.v15i1.839.201-214.

[19] P. E. Wardani, Y. Siagian, and M. Ihsan, "Sistem Pakar Untuk Diagnosa Penyakit Sapi Menggunakan Metode Bayes," *Build. Informatics, Technol. Sci.*, vol. 4, no. 2, pp. 413–421, 2022, doi: 10.47065/bits.v4i2.2197.

[20] I Putu Dody Suarnatha and I Made Agus Oka Gunawan, "Implementasi Metode Certainty Factor dalam Sistem Pakar Deteksi Penyakit Pencernaan pada Manusia," *J. CoSciTech (Computer Sci. Inf. Technol.*, vol. 3, no. 2, pp. 73–80, 2022, doi: 10.37859/coscitech.v3i2.3872.

[21] M. Mahendra, R. Pane, and R. Rohani, "Analisis Perbandingan Sistem Pakar dalam Mendiagnosa Penyakit Limfoma Hodgkin Menggunakan Algoritma Teorema Bayes dan Certainty Factor," *Build. Informatics, Technol. Sci.*, vol. 5, no. 1, Jun. 2023, doi: 10.47065/bits.v5i1.3560.

[22] A. Wenda, A. Adi Suryanto, S. Nur Alam, and K. Suhada, "Sistem Pakar Untuk Mendiagnosa Penyakit Paru-Paru dengan Menggunakan Metode Teorema Bayes," *J. MEDIA Inform. BUDIDARMA*, vol. 7, no. 1, pp. 82–88, 2023, doi: 10.30865/mib.v7i1.5394.

[23] P. Febrianty and A. H. Nasyuha, "Penerapan Kombinasi Metode K-Nearest Neighbor dan Certainty Factor Dalam Mendiagnosa Bos Taurus Disease," vol. 2, pp. 115–126, 2023, doi: 10.53513/jursi.v2i1.5142.

[24] A. Seppewali, W. H. Mulyo, and R. Riswan, "Sistem Pakar Diagnosa Kerusakan Motor Suzuki Smash Titan 115 Cc Menggunakan Metode Forward Chaining," *J. Teknol. Dan Sist. Inf. Bisnis*, vol. 5, no. 1, pp. 13–20, 2023, doi:10.47233/jteksis.v5i1.728.

[25] A. HARKAMSYAH, "Sistem Pakar Stunting Pada Balita Menggunakan Metode Forward Chaining & Naïve Bayes," *J. Sains Inform. Terap.*, vol. 1, no. 2, pp. 115–119, 2022.

[26] M. Hutasuhut, E. F. Ginting, and D. Nofriansyah, "Sistem Pakar Mendiagnosa Penyakit Osteochondroma dengan Metode Certainty Factor," *JURIKOM (Jurnal Ris. Komputer)*, vol. 9, no. 5, pp. 2407–389, 2022, doi: 10.30865/jurikom.v9i5.4959.

[27] F. H. Rofifah, Z. Azmi, and U. F. S. S. Pane, "Sistem Pakar Mendiagnosa Penyakit Sesak Nafas Pada Penderita Paru Menggunakan Metode Certainty Factor," *J. Sist. Inf. TGD*, vol. 2, pp. 82–90, 2023.

[28] D. Hidayatullah and I. FITRI, "Sistem Pakar Delirium Pasien COVID-19 Pada Lansia Menggunakan Metode Certainty Factor dan Forward Chaining," *434-442*, vol. 6, no. 1, pp. 434–442, 2022, doi: 10.30865/mib.v6i1.3503.

[29] Praditya, F. E. Nastiti, and R. Susanto, "Diagnosis Penyakit Kulit Dengan Metode Certainty Factor pada Sistem Pakar Diagnosis of Skin Diseases Using the Certainty Factor Method in an Expert System," *Smart Comp Jurnalnya Orang Pint. Komput.*, vol. 13, no. 105, pp. 702–714, 2024, doi: 10.30591/smartcomp.v13i3.7146.

[30] F. R. B. Putra, A. Fadlil, and R. Umar, "Application of Forward Chaining Method , Certainty Factor , and Bayes Theorem for Cattle Disease," *Int. J. Adv. Sci. Eng. Inf. Technol.*, vol. 14, no. 1, pp. 365–374, 2024, doi: 10.18517/ijaseit.14.1.18912.

[31] C. Y. Gobel, M. Lasena, M. A. Puspa, and S. A. Utiarahman, "Analisis Perbandingan Metode Teorema Bayes dan Certainty Factor Pada Diagnosis Gangguan Kecemasan," *J. MEDIA Inform. BUDIDARMA*, vol. 8, pp. 1262–1268, 2024, doi: 10.30865/mib.v8i3.7683.

[32] C. I. Angkat, I. M. Sianturi, S. H. Sinambela, M. Iqbal, and R. Farta, "Sistem Pakar Diagnosa Rheumatoid Arthritis dengan Menerapkan Algoritma Teorema Bayes," *J. Ilmu Komput. dan Sist. Inf.*, vol. 7, no. 1, pp. 8–15, 2024, doi: 10.55338/jikomsi.v7i1.2610.

[33] I. Erdiansyah, M. I. N. Syahputra, and M. Dian, "Pengelolaan Diagnosis Penyakit Tanaman Padi Menggunakan Metode Teorema Bayes Management of Rice Plant Disease Diagnosis Using Bayes Theorem Method," *JIKO (JURNAL Inform. Dan Komputer)*, vol. 8, no. 2, pp. 393–403, 2024, doi: 10.26798/jiko.v8i2.1315.

[34] M. I. Mohd Sani, N. A. S. Abdullah, and M. Mohd Rosli, "Review on hypertension diagnosis using expert system and wearable devices," *Int. J. Electr. Comput. Eng.*, vol. 12, no. 3, pp. 3166–3175, 2022, doi: 10.11591/ijece.v12i3.pp3166-3175.