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Certainty Factor Algorithm Approach for Early Stage of Cattle Disease Diagnosis Using Mobile-Based Expert System

Budy Satria*[1], Nurfiah[2], Bima Prakasa[3]

[1,2,3]Faculty of Information Technology, Department of Informatics, Universitas Andalas, Indonesia

Email: [1]budy.satria@it.unand.ac.id

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Abstract

Cattle are one of the livestock that play a crucial role in meeting the demand for meat and milk, as well as providing a source of income for farmers, particularly in various regions of Indonesia. Diseases in cattle pose a serious problem due to the lack of knowledge about accessing veterinary services, a lack of understanding among farmers, and the high cost and time required for consultations, which are significant obstacles for farmers in identifying diseases in cattle early, potentially leading to death. Limitations in accessing veterinary services, a lack of understanding among farmers, and the high cost and time required for consultations are significant obstacles to treating diseases in cattle. This study aims to assist farmers in diagnosing cattle diseases using an expert system based on the observed symptoms. The application of the expert system employs a certainty factor algorithm approach, utilizing the knowledge base of animal experts in the diagnosis process. This study used 6 types of diseases and 34 lists of symptoms in cattle. Based on the results of implementing the Certainty Factor method, it was concluded that the expert system was able to diagnose cattle diseases, specifically worms, with a confidence level of 90.1504%. This is certainly influenced by the selection of symptoms, the user's confidence value for each symptom, and the combination of the confidence values from experts. In addition, testing was also carried out on the functionality of the expert system built; the results obtained showed that all functionalities run well and as expected. Thus, the final conclusion is that expert systems can be a solution and help farmers diagnose cattle diseases. Suggestions for further research include comparing algorithms to achieve better accuracy and disease identification in specific cattle species.

Keywords : *Cattle Disease Diagnosis, Certainty Factor, Early Detection, Expert System, Mobile-Based*

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1. INTRODUCTION

Cows are a type of livestock that provide economic benefits to the community, such as a source of food, milk, meat, manure, and even absorbing labor in the livestock sector [1]. One of the strategic factors in economic development in a region is through cattle farming to support food security in Indonesia [2] [3]. Some factors that need to be considered in cattle farming are choosing the right type of superior cattle based on climate conditions, care and supervision of the condition of livestock, and health care according to the animal's growth phase [4]. Along with the large number of cattle farms available, this certainly presents a challenge in the field of animal health, namely that cattle are susceptible to disease, which can cause significant financial losses [5]. Cattle breeders naturally want to produce high-quality cattle, so they must pay close attention to their health and the environment in which they live. Cases of cattle disease are common, despite farmers maintaining their pens, providing feed, and offering various nutritional supplements. Disease in cattle is a serious problem due to the lack of ability of breeders to detect disease early, resulting in delays in treatment and ultimately, death [6]. This is undoubtedly challenging and costly because access to professional and veterinary care can occasionally be restricted, particularly in rural areas [7].

Cattle breeders rely heavily on animal disease experts due to their limited understanding of disease symptoms in cattle, the types of cattle diseases, and their treatment. Therefore, a system is

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needed that can mimic the expertise of experts in diagnosing cattle diseases based on the symptoms that appear during an initial examination [8]. The solution offered to answer this problem is the use of artificial intelligence technology in the form of creating an expert system for diagnosing cattle diseases [9]. A computer system that enables computational design techniques to mimic and classify the decision-making process of a human expert is known as an expert system [10].

Distributing an expert's knowledge and expertise into a computer system is the primary objective of creating an expert system [11].

An expert system is a tool that utilizes human knowledge and implements it into a computer, with the goal of enabling users to solve specific problems with the system's support, much like communicating with an expert [12]. Expert systems are a part of artificial intelligence technology [13], [14], which can perform tasks typically done by humans with great effectiveness. Expert systems offer considerable potential to aid in the diagnosis of livestock diseases, particularly in cattle, which are a valuable commodity in Indonesia [15].

In this study, the expert system method used is the Certainty Factor. This factor represents the degree of confidence in a particular symptom contributing to the diagnosis [16]. The Certainty Factor method, also known as the certainty factor, is a technique applied to determine the level of certainty of an event (hypothesis or fact) by referring to expert assessments and existing evidence [17]. The assessment of Belief (MB) is used in the Certainty Factor approach to assess the degree of belief, while the quantification of skepticism (MD) is used to quantify the degree of skepticism based on a hypothesis impacted by various pertinent facts [18]. Certainty Factor integrates the trust value obtained from experts to overcome uncertainty, apart from the trust value from users [19].

Previous research on the implementation of the Certainty Factor method for the early detection of childhood disease diagnosis [20] The study's results showed that the accuracy levels in diagnosing RFA (Acute Rhinopharyngitis), GEA (Acute Gastroenteritis), UTI (Urinary Tract Infection), Pharyngitis, and DM (Diabetes Mellitus) were 95%, 70%, 70%, 68%, and 50%, respectively. Research using Certainty Factor has also been conducted for diagnosing goat diseases [21] The results showed that the certainty factor method could identify livestock diseases in goats, with a result of 0.28 for pink eye. Other research has also been conducted to detect chicken diseases [22] The research results showed that the Certainty Factor method expert system can help farmers quickly obtain information about the symptoms and types of diseases in chickens. Based on previous research, it can be concluded that an expert system utilizing the Certainty Factor method can be employed for the early detection of cattle diseases. Other studies have also been conducted to test the certainty factor method, namely Expert System Application for Diagnosing Diseases in Cats Using a Web-Based [23]. In addition, diagnosing various diseases based on the symptoms experienced by rabbits [24].

Previous research has identified several research gaps, including the fact that most existing expert systems for identifying cattle diseases are web-based applications. Meanwhile, the Certainty Factor method has not been widely utilized in mobile application development. Therefore, it is crucial to develop mobile-based applications that enable farmers to diagnose diseases efficiently and accurately. The proposed novelty is the development of an Android application utilizing an expert system with a Certainty Factor approach to enable farmers to independently detect cattle diseases. For easier access, network models must be implemented on mobile devices [25]. The application features a simple interface that can be operated via mobile devices, focusing on common symptoms frequently encountered. The aim of this research was to develop an expert system that provides farmers with knowledge about the importance of early symptom screening in cattle, based on expert knowledge, considering the accuracy of the Certainty Factor method in disease diagnosis.

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2. METHOD

2.1. Research Flow Diagram

This research involved several sequential steps to obtain appropriate results. The research flowchart used is shown in Figure. 1 below.

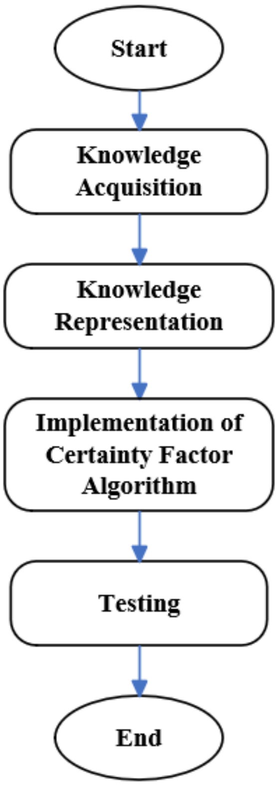

Figure 1. Research Flow Diagram

The research stages in Figure 1 can be explained as follows.

1) Start: At this stage, the implementation of research activities begins.
2) Knowledge Acquisition: The knowledge integrated into the expert system is obtained from literature and journal articles related to cattle symptoms and diseases. At this stage, interviews with experts are also conducted to determine the value of CFexpert as a knowledge base.
3) Knowledge Representation: Information storage in the knowledge system is represented through an IF-THEN rule, which includes facts about symptoms and diseases in cattle.
4) Implementation of the Certainty Factor Algorithm: This stage is the implementation of an expert system using the Certainty Factor method.
5) Testing: The stage for testing whether the algorithm and expert system that have been created are running according to procedure, or whether errors may still occur.

2.2. Certainty Factor Algorithm

Certainty Factor is a method that shows the certainty of facts in the form of metrics used in expert systems [26]. Based on literature studies, it is also known that there are differences in concepts and rules between the Certainty Factor (CF) method and other methods, which are expressed in the following formula [27]:

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

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Where CF stands for Certainty Factor, H stands for Hypothesis, E stands for Evidence, MB stands for Measures of Belief, and MD stands for Measures of Disbelief. The combination of various CF values obtained through this method is then used in the overall evaluation and diagnosis of the disease. The following is a breakdown of the CF combinations applied in the disease diagnosis process [28]:

$$CFSymptom = CFExpert\,[H] * CFUser\,[E] \quad (2)$$
$$CFCombine = CFold + CFSymptom * (1 - CFold) \quad (3)$$
$$CFPercentage = CFCombine * 100\% \quad (4)$$

3. RESULT

In this discussion, several stages will be carried out as steps in accordance with the research flow diagram, starting from Knowledge Acquisition, Knowledge Representation, Implementation of Certainty Factor, and Testing.

3.1. Knowledge Acquisition

Knowledge acquisition is a dialogue between experts and systems. Knowledge acquisition facilities are used to input facts that are in line with scientific developments [29]. At this stage, the data collection results will be processed, comprising disease type data, symptom description data, parameter value determination, and confidence level determination for each symptom, derived from both experts (CF Expert) and users (CF User). Data on cattle disease types are presented in Table 1 below.

Table 1. Types of Cattle Diseases

No	Code	Name of Diseases
1	P01	Jembrana Disease
2	P02	Lantana Poisoning
3	P03	Worms
4	P04	Persistent Corpus Luteum
5	P05	Surra
6	P06	Bovine Ephemeral Fever

Based on Table I, data on the types of cattle diseases obtained from observations, literature studies, and interviews, there are six diseases in cattle: Jembrana, Baliziekte, Worms, Persistent Cospus Luteum, Surra, and Bovine Ephemeral Fever. Data describing symptoms in cattle, which can include as many as 34 symptoms, are presented in Table 2 as follows.

Table 2. Cattle Symptoms Data

No	Code	Name of Diseases
1	G01	Fever of 38-40 degrees Celsius
2	G02	Severe swelling of the lymph nodes
3	G03	Sweating blood
4	G04	Diarrhea is often mixed with blood
5	G05	Excessive salivation
6	G06	Weight loss
7	G07	Sores on the mucous membranes of the mouth
8	G08	Paleness or anemia
9	G09	Mucus or watery eyes
10	G10	Inflammation of the nose
11	G11	Itching and restlessness of the cow
12	G12	Scabs on the skin
13	G13	Pain in certain parts of the body

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14	G14	Diarrhea
15	G15	Thin
16	G16	Lack of appetite
17	G17	Dull and erect fur
18	G18	Dropping the ears of the cow
19	G19	No heat
20	G20	Inflammation of the uterine wall
21	G21	Pus buildup in the reproductive tract
22	G22	Calf death in the mother's womb
23	G23	The fetus is rotting and decomposing in the womb
24	G24	Decreased appetite
25	G25	Hair loss
26	G26	The underside of the chin and feet appear dirty
27	G27	Whirling aimlessly
28	G28	Inflammatory mucus discharge from the nose and eyes
29	G29	Walking unsteadily
30	G30	Convulsions
31	G31	Visible trembling of the body
32	G32	Runny nose and eyes
33	G33	Muscle pain and stiffness
34	G34	Increased breathing and heart rate

The data used to determine the parameter values for the confidence level are presented in Table 3, as follows.

Table 3. Certainty Factor Weight Parameter Value Data

No	Certainty Level	MB Value (CF Expert)	MD Value (CF User)
1	Not Sure	0	0
2	Don’t Know	0.2	0.1
3	Slightly Sure	0.4	0.3
4	Fairly Sure	0.6	0.5
5	Confident	0.8	0.7
6	Very Confident	1	0.8

The confidence values of the symptoms are presented in Table 4, which will serve as the basis for calculations in the system created.

Table 4. Expert and User Certainty Value Data

No	Name and Disease Code	Symptom Code	CF Pakar	CF User
1	Jembrana Disease (P01)	G01	**0.6**	**0.8**
2		G02	**0.8**	**0.5**
3		G03	**0.8**	**0.5**
4		G04	**0.6**	**0.3**
5		G05	**0.6**	**0.3**
6		G06	**0.6**	**0.3**
7		G07	**0.6**	**0.3**
8	Lantana Poisoning (P02)	G01	**0.6**	**0.8**
9		G08	**0.6**	**0.5**
10		G09	**0.8**	**0.5**
11		G10	**0.8**	**0.5**
12		G11	**0.8**	**0.5**

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13		G12	**0.8**	**0.3**
14		G13	**0.6**	**0.5**
15		G09	**0.8**	**0.5**
16		G14	**0.8**	**0.5**
17	Worms	G15	**0.8**	**0.8**
18	(P03)	G16	**0.8**	**0.3**
19		G17	**0.8**	**0.8**
20		G18	**0.8**	**0.3**
21		G19	**0.8**	**0.8**
22		G20	**0.6**	**0.3**
23	Persistent Corpus Luteum	G13	**0.6**	**0.5**
24	(P04)	G21	**0.6**	**0.8**
25		G22	**0.6**	**0.3**
26		G23	**0.6**	**0.5**
27		G01	**0.6**	**0.8**
28		G24	**0.8**	**0.5**
29		G25	**0.8**	**0.5**
30	Surra	G26	**0.8**	**0.8**
31	(P05)	G27	**0.8**	**0.5**
32		G28	**0.8**	**0.5**
33		G29	**0.8**	**0.3**
34		G30	**0.8**	**0.5**
35		G01	**0.6**	**0.8**
36		G24	**0.8**	**0.5**
37	Bovine Ephemeral Fever	G31	**0.8**	**0.8**
38	(P06)	G32	**0.8**	**0.8**
39		G33	**0.8**	**0.3**
40		G34	**0.6**	**0.5**

3.2. Knowledge Representation

The knowledge contained in an expert system is presented in the form of if-then rules. These rules explain the relationship between signs and certain disease categories [30]. This representation enables the system to track and match available information with rule premises, thereby reaching appropriate conclusions. The knowledge representation is presented in Table 5 below.

Table 5. Knowledge Representation

Code of Rules	IF- THEN Rules
R01	If fever of 38-40 degrees Celsius AND severe swelling of the lymph glands AND sweating, bloody AND diarrhea often mixed with blood AND excessive salivation AND weight loss AND sores on the mucous membranes of the mouth THEN **Jembrana Disease**
R02	If fever with a temperature of 38-40 degrees Celsius AND Pale or anemic AND Mucus or watery eyes AND Inflammation in the nasal area AND Itching and the cattle are restless AND Scabs on the skin AND Pain in certain parts of the body THEN **Lantana Poisoning**
R03	If the eyes are slimy or watery AND diarrhea AND thin AND no appetite AND fur is dull and standing up, AND the cow's ears look droopy THEN **Worms**
R04	If there is no heat AND inflammation of the uterine wall AND pain in certain parts of the body AND accumulation of pus in the reproductive organs AND death of the

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	calf in the mother's womb AND the fetus in the womb rots and undergoes a decomposition process in the womb THEN **Persistent Corpus Luteum**
R05	If fever of 38-40 degrees Celsius AND your appetite will decrease AND your hair will fall out AND the bottom of your chin and feet will look dirty AND you will spin around aimlessly, there will be inflammatory fluid coming out of your nose and eyes, AND you will walk unsteadily, AND you will have convulsions THEN **Surra**
R06	If fever with a temperature of 38-40 degrees Celsius AND your appetite will decrease AND your body will appear to be shaking AND your nose and eyes will be runny, AND your muscles will feel sore and stiff, AND your breathing and heart rate will increase THEN **Bovina Ephemeral Fever**

3.3. Implementation of The Certainty Factor Algorithm

Calculations using the Certainty Factor method to detect cattle disease can be carried out based on the symptoms selected by the user, as shown in Table 6 below.

Table 6. User Selected Symptoms

No	Symptoms Code	CFUser
1	P01	0.8
2	P02	0.5
3	P09	0.5
4	P014	0.5
5	P015	0.8
6	P016	0.3

Looking for CF Symptoms is as follows:

$\mathcal{CF}G01[H,E] = \mathcal{CF}[H] * \mathcal{CF}[E] = 0.6 * 0.8 = 0.48$

$\mathcal{CF}G02[H,E] = \mathcal{CF}[H] * \mathcal{CF}[E] = 0.8 * 0.5 = 0.40$

$\mathcal{CF}G09[H,E] = \mathcal{CF}[H] * \mathcal{CF}[E] = 0.8 * 0.5 = 0.40$

$\mathcal{CF}G014[H,E] = \mathcal{CF}[H] * \mathcal{CF}[E] = 0.8 * 0.5 = 0.40$

$\mathcal{CF}G015[H,E] = \mathcal{CF}[H] * \mathcal{CF}[E] = 0.8 * 0.8 = 0.64$

$\mathcal{CF}G016[H,E] = \mathcal{CF}[H] * \mathcal{CF}[E] = 0.8 * 0.3 = 0.24$

Next is to find the CF Combination in the following way:

$CF_{Combine}$ = **P01 (Jembrana Disease) → G01, G02**

$CF_{Combine}$ $= \mathcal{CF}[H,E]\ G01, G02$

$= \mathcal{CF}[H,E]\ G01 + \mathcal{CF}[H,E]\ G02 * (1 - \mathcal{CF}[H,E]\ G01)$

$= 0.48 + 0.40 * (1 - 0.48)$

$= 0.48 + 0.40 * 0.52 = 0.688$

$CF_{Percentage}$ = CFCombine *100%

$= 0.688 + 100\% = \mathbf{68.8}\%$

$CF_{Combine}$ = **P03 (Worms) → G09, G14, G15, G16**

$CF_{Combine}$ $= \mathcal{CF}[H,E]\ G09, G14$

$= \mathcal{CF}[H,E]\ G09 + \mathcal{CF}[H,E]\ G14 * (1 - \mathcal{CF}[H,E]\ G09)$

$= 0.40 + 0.40 * (1 - 0.40)$

$= 0.40 + 0.40 * 0.6 = 0.64_{old1}$

$CF_{Combine}$ $= \mathcal{CF}[H,E], G15$

$= \mathcal{CF}[H,E]old + \mathcal{CF}[H,E]\ G15 * (1 - \mathcal{CF}[H,E]old)$

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$$= 0.64 + 0.64 * (1 - 0.64)$$
$$= 0.64 + 0.64 * 0.36 = 0.8704_{\mathbf{old2}}$$
$$CF_{Combine} = \mathcal{CF}[H,E], G16$$
$$= \mathcal{CF}[H,E]old_{,} + \mathcal{CF}[H,E]\ G16 * (1 - \mathcal{CF}[H,E]old)$$
$$= 0.8704 + 0.24 * (1 - 0.8704)$$
$$= 0.8704 + 0.24 * 0.1296 = 0.901504$$
$$CF_{Percentage} = CF_{Combine} * 100\%$$
$$= 0.901504 * 100\% = \mathbf{90.1504}\%$$

3.4. System Design

This system features a simple and user-friendly interface. The application display begins with the main page, which leads to the next menu. The main page features several menus, including Diagnosis, Disease Type, Symptom List, Diagnosis History, Help, and About Us. The Disease Type page contains information on six types of diseases. Next, the Symptom List page displays a list of 34 symptoms for users to fill in. The core feature of this application is the Diagnosis page, which directs users to fill in several cattle symptoms, then assigns a weighted score, called the User CF. After users select several symptoms based on the level of confidence observed in the cattle's condition, they are directed to click the Diagnosis menu, which displays the examination results calculated by the application using a certainty factor algorithm on the Results page. The Diagnosis History page displays a sequence of all application usage information that has been automatically saved by the user. The Help page contains information provided to users to guide them in using the application for its intended purpose. Complete information will appear in each menu on the Home page. About Us is the last menu item in the application. This menu displays information about the cattle disease expert system development team and the current version of the application. The overall appearance and features of the interface are illustrated in Figure 2.

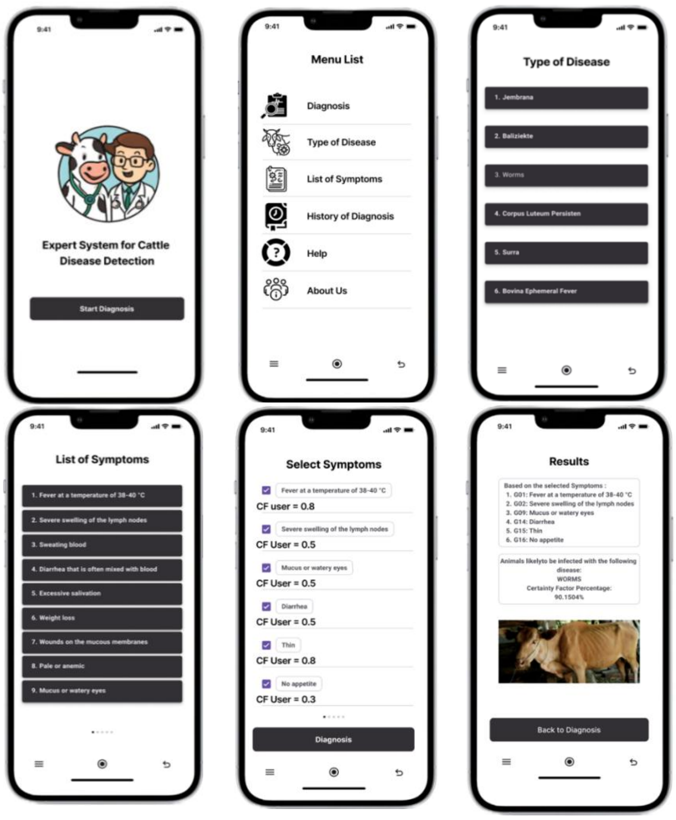

Figure 2. Application User Interface

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3.5. Testing

In the process of developing applications or software, crucial steps that need to be taken to ensure or create quality applications are to carry out testing [31]. The purpose of system testing is to ensure that the software or system operates as intended and can perform its required functions [32]. In this study, a system test was carried out using the Blackbox method to test whether all application features run as expected [33]. An approach that compares the system output with the provided input to evaluate software functioning based on specifications, without considering the source code into account [34]. Testing focuses on the functionality of all the features in the application [35]. The test results using the Black Box method are presented in Table 7 below.

Table 7. BlackBox Testing Results

System Functionality			
Input	**Expected results**	**Output**	**Results**
Click the application icon	Can open applications	Application running	Succeed
Click the start diagnosis menu	Can display the main page of the application	The application displays the main page	Succeed
Click the Diagnosis menu	Can display the symptom selection page and display the diagnosis results in the application.	The application displays the symptom selection page and displays the diagnosis results.	Succeed
Click the disease type menu	Can display the disease type page in the application	The application displays the disease type page.	Succeed
Click the symptom list menu	Can display the symptom list page on the application	The application displays a symptom list page.	Succeed
Click the History of Diagnosis menu	Can display the History of Diagnosis page in the application	The application displays the History of Diagnosis page.	Succeed
Click the help menu	Can display the help page in the application	The application displays the help page.	Succeed
Click the About Us menu	Can display the About Us page on the application	The application displays the About Us page.	Succeed

Based on the test results using the Blackbox method in Table 7, all features in the application ran well as expected and successfully obtained the final results in each test.

4. DISCUSSIONS

The Certainty Factor algorithm approach for early-stage disease diagnosis in cattle has been successfully implemented in this study. At the results stage, the author has completed the research, which involved collecting data on disease types in cattle, various symptom data, determining Expert CF and User CF, knowledge representation, implementing the Certainty Factor algorithm, designing the user interface for application development, and testing using the Black Box method. In diagnosing diseases in cattle, the author reviewed previous related research, as shown in Table 8 below.

Table 8. User Selected Symptoms

Previous research	Methods used	Diagnosis Results
[36]	Expert System - Bayes Theorem Algorithm	83,3%
[37]	Expert System - Dempster Shafer	59%
[38]	Expert System - Bayesian Network	41,67%
Proposed method	Expert System – Certainty Factor	**90.1504%**

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Table 8 shows that the research using the Certainty Factor Algorithm was successfully implemented with a percentage of 90.1504%. The benefits of the Certainty Factor approach are pertinent to the nature of the issue under investigation. The Certainty Factor is better suited for IF-THEN rule-based expert systems that depend on expert knowledge, as it enables the depiction of expert confidence levels through certainty values. This method enables users to learn new information and evaluate diagnostic findings. However, the author provides suggestions for further research development, utilizing algorithm comparisons to achieve the optimal percentage value.

Although the developed expert system is capable of providing cattle disease diagnoses based on the Certainty Factor method, this research has several limitations. The accuracy of the diagnostic results is highly dependent on the completeness and quality of the knowledge base obtained from experts. If there are changes in disease patterns or new symptoms not yet accommodated in the knowledge base, the system cannot automatically adjust. Furthermore, the CF method employs subjective confidence levels, as they are determined based on expert assessments. This can lead to differences in diagnostic results if certainty levels are assigned by different experts. Finally, the mobile application system still focuses on six types of diseases and does not cover all possible disease variations in the field. System testing is limited to functional (black-box) testing, resulting in a more quantitative evaluation of performance. Therefore, performance comparisons with other methods have not been conducted.

These limitations open up opportunities for further research to develop systems with broader disease coverage, combine Certainty Factor with other methods, and evaluate performance using larger and more diverse datasets.

5. CONCLUSION

The Certainty Factor Algorithm approach to detecting cattle diseases has been successfully implemented. The disease data obtained were 6 types of cattle diseases, while the symptom data used were 34 symptom lists. The knowledge base used is the IF-THEN concept. During the diagnosis process, users can select multiple symptoms, along with the confidence levels provided in the application. The final diagnosis result is then obtained by combining expert confidence levels to support accurate disease identification, similar to an expert. Based on the Certainty Factor Algorithm test, the user selected 6 symptoms along with their respective confidence levels, namely G1 (0.8), G2 (0.5), G9 (0.5), G14 (0.5), G15 (0.8), and G16 (0.3), then obtained a diagnostic assessment result of 90.1504% that the cattle had worm disease. Testing the system's functionality was also demonstrated through black-box testing, resulting in the conclusion that all features were functioning properly. Suggestions for further research include comparing expert system algorithms for detecting cattle diseases to achieve more accurate values. Additionally, focus on disease identification in specific types of cattle**.** This research enhances informatics studies in terms of modeling, knowledge, rule-based reasoning, and the application of artificial intelligence algorithms in functionally proven expert systems, as well as in the field of animal husbandry.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest between the authors or with the research object in this paper.

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