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Coffee plant disease identification system using the certainty factor method

N W Rini[1], E R Arumi[1*] and M Hanafi[1]

[1] Informatics Engineering Study Program, Muhammadiyah University of Magelang, Magelang, Indonesia
[*]Corresponding author email: arumi@ummgl.ac.id

Abstract

The cultivation of the coffee plant is significant in the field of agriculture and is practiced worldwide, especially in Indonesia, as a major producer. Farmers find it difficult to promptly identify and treat the disease, resulting in huge losses. To increase efficiency, the proposed system uses the certainty factor method for disease identification. Implementation of an identification system using the factor certainty method to speed up the provision of disease information and solutions to coffee plant diseases based on predetermined criteria and weights. This research uses the forward chaining method for planning, monitoring and future-oriented reasoning. Furthermore, the Certainty Factor technique guarantees precise outcomes by evaluating user-experienced results in accordance with the confidence level associated with the symptoms. The successful implementation of the identification system was confirmed through black box testing. Black-box alpha testing shows the system functions well. Black-box Beta testing, involving 10 users, resulted in a success rate of 87%, indicating user satisfaction.

Keywords

Coffee plant disease, Identification system, Certainty factor method

Introduction

Coffee plants from the genus Coffea are one of the important plants in agriculture and the food and beverage industry. Coffee is a world commodity that is cultivated in more than 50 countries. Two types of coffee plants that are commonly known are Robusta coffee (*Coffea Canephora*) and Arabica coffee (*Coffea Arabica*). Indonesia stands as the foremost coffee-producing nation in Southeast Asia and ranks third globally, following Brazil and Vietnam [1]. Coffee plants require a tropical or subtropical climate with a stable temperature. Even rainfall and soil fertility are also very important in the process of cultivating coffee plants. Arabica coffee plants grow at higher altitudes than Robusta coffee.

Coffee plants are one of the plants that are often attacked by pests and diseases. Late treatment can cause coffee plant diseases to spread further. As a consumer, you naturally opt for high-quality coffee. Generally, the preferences of coffee consumers

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encompass three aspects: flavor (quality) and uniformity, cleanliness and purity, and the health and safety of consumers [2]. In the Ngemplak area there is the MURIH RAHARJO coffee farmer group which holds sharing session meetings every month. Many coffee farmers have difficulty and are late in identifying pests and diseases that attack coffee plants, especially beginners. If farmers lack knowledge about the pests and diseases affecting coffee plants, the impact will be difficulty for farmers to carry out treatment and there is a high possibility of experiencing crop failure, causing huge losses.

Seeing the problems above, a disease identification system is needed in coffee plants which must be carried out correctly. So that later it can be used by the community, especially coffee farmers, to make it easier to deal with diseases in coffee plants. The certainty factor method and the forward chaining method are techniques that can be utilized for the identification of diseases in coffee plants. Because the forward chaining method has the characteristics of planning, monitoring, controlling, serving the future, directing information, reasoning from the bottom up, working forward to obtain solutions that are in accordance with reality [3]. The certainty factor offers the benefit of generating computation outcomes aligned with the user's experience based on the confidence level in the symptoms, so that it can produce answers to uncertain situations, thereby producing true or more accurate facts [4].

Therefore, in order to increase efficiency in identifying diseases in coffee plants, this research is entitled "Coffee Plant Disease Identification System Using the Certainty Factor Method". In this particular system, the forward chaining inference engine will reveal symptoms or characteristics of disease based on existing knowledge in the system. Then the farmer (user) will enter the symptoms seen on the coffee plant, and the certainty factor will produce a certainty value related to the symptoms entered by the user.

Research conducted by [2] and [5] proposed an expert system to diagnose coffee plant diseases and increase corn production using the Certainty Factor method. Khula & Minardi's research achieved a certainty level of 90%, validated by comparing the results of experts and farmers, while Sucipto et al. reported 91% accuracy in disease identification. In addition, [6] identified oil palm pests in East Kalimantan, using the Certainty Factor to calculate the certainty of pest attacks, so that the highest pest impact was termite species at 88.8% [7] introduced a cocoa plant disease diagnosis system, simplifying farmers' disease identification and saving consultation time. Finally, [8] designed a Mastitis diagnosis system in Etawah goats, offering an effective solution for goat farmers. These studies, each focusing on a different aspect of agriculture, use the Certainty Factor method to address specific issues, providing tailored disease predictions and management solutions for a variety of crops and livestock.

Methods

Expert systems must be able to work in uncertain conditions. The method used is to determine which rule will be implemented, then the rule is executed, the process is

repeated until a result is found and a Certainty factor is used to indicate the certainty value of a diagnosis [9]. From this theory, it can be briefly explained that forward chaining is a method for obtaining conclusions from these facts [10]. The Certainty Factor (CF) technique is an approach that establishes a quantification of certainty related to a rule, indicating the extent of expert confidence in the current issue. By using CF, the experts' beliefs will be answered [11]. The expert's Certainty Factor (CF) value is calculated using equations 1 and 2, where the formula for obtaining the CF(HE) value is as follows:

$$CF(H,E) = CF(E) * CF(Rule) \quad (1)$$

$$CF(H,E) = CF(User) * CF(Rule) \quad (2)$$

Meanwhile, the formula for finding the hypothesis certainty factor value which originates from different evidence can be seen in equation 3.

$$CF\text{combine}\,(CF1, CF2) = CF1 + CF2\,(1 - CF1) \quad (3)$$

In the Certainty Factor approach, the certainty factor is used to assess the level of certainty or lack of confidence in making decisions or judgments based on existing evidence or facts. The varying types of CF values of various terms that describe the level of certainty and uncertainty are explained in Table 1.

Table 1. Certainty value in the certainty factor method [12]

Certainty Level	Certainty Factor
There isn't any	0
Don't know	0.2
Not sure	0.4
Sure enough	0.6
Certain	0.8
Very confident	1

Table 2. Symptom data

Code	Symptom
S1	Yellow-orange spots like powder
S2	Yellow spots appear, then turn brown
S3	Brown spots appear to join together
S4	Leaves dry and fall
S5	Bare tree without leaves
S6	There are round, reddish brown or dark brown spots
S7	In old spots there is a gray-white center
S8	The midline of the spot is less than 5 mm and has rings
S9	The affected branches or twigs wilt suddenly
S10	The fungus forms a pink crust
S11	Small reddish orange spots on wood that is generally dead
S12	The appearance of small brown or black spots on coffee leaves
S13	Dead coffee branch
S14	The appearance of pink bubbles on leaves or twigs
S15	Loss of flowers and immature fruit
S16	Yellowing leaves
S17	Rolling leaves
S18	Has yellow rings or spots
S19	Plant growth is stunted

When diagnosing coffee plant problems, recognizing the symptoms is critical. Agricultural extension workers play an important role in ensuring certain diseases and pests attack coffee plants. The following symptom data was obtained from an interview with Pak Sriyanto, chairman of the Murih Raharjo farmer group. Symptom data can be seen in Table 2.

Apart from symptom data, there are also interview results in the form of disease data from the same source. The following disease data results is visible in Table 3.

Table 3. Disease data

Code	Disease Name
D1	Coffee Leaf Rust (Himelia Vastatrix)
D2	Coffee Leaf Spot (Corcespora Coffeicola)
D3	Upas mushroom (Upasia Salmonicolor)
D4	Anthracnose on leaves and twigs
D5	Dwarf Yellow Virus (Coffee Ringspot Virus)

The rule base system is one part of the expert system which consists of rules in the form of IF-THEN. The utilization of this decision table allows the observation of the decision tree outlined in Table 4. The CF value is calculated using equations 1 and 2.

Table 4. Symptoms and disease decision table

Symptom	Disease					CF value
	D1	D2	D3	D4	D5	
S1	✓	-	-	-	-	0.6
S2	✓	-	-	-	-	0.6
S3	✓	-	-	-	-	0.6
S4	✓	-	-	✓	-	0.8
S5	✓	-	-	-	-	1
S6	-	✓	-	-	-	0.8
S7	-	✓	-	-	-	0.6
S8	-	✓	-	-	-	0.4
S9	-	-	✓	-	-	0.6
S10	-	-	✓	-	-	0.8
S11	-	-	✓	-	-	0.8
S12	-	-	-	✓	-	0.6
S13	-	-	-	✓	-	0.8
S14	-	-	-	✓	-	0.6
S15	-	-	-	✓	-	0.6
S16	-	-	-	-	✓	0.8
S17	-	-	-	-	✓	0.6
S18	-	-	-	-	✓	0.8
S19	-	-	-	-	✓	0.6

Results and Discussion

Implementation of certainty factor calculations

To include the certainty factor calculation into the computing system, the process can be started by determining the CF(H,E) value using equations 1 and 2. Then look for the Cfcombine value with equation 3 to find out the amount of accuracy for each disease

symptom that has been selected. The procedure of deriving the certainty factor value relying on the theoretical question and the responses to the test are observable in Table 5.

Table 5. Symptoms and disease Certainty Factor (CF) value

Code	Expert Value	User Symptom Value	CF(H,E)	Disease
S2	0.6	0.2	0.12	
S3	0.6	0.6	0.36	D1
S5	1	0.8	0.8	
S9	0.6	0.4	0.24	D3
S11	0.8	0.8	0.48	

From the results entered by the farmer, the Cfcombine can be calculated using the certainty factor formula, namely:

1. D1 / Coffee Leaf Rust *(Himeleia Vastatrix)*

$$\begin{aligned} \text{Cfcombine CF(A)} &= \text{CF(1)} + \text{CF(2)} * [1 - \text{CF(1)}] \\ &= 0.12 + 0.36 * [1 - 0.12] \\ &= 0.4368 \end{aligned}$$

$$\begin{aligned} \text{Cfcombine CF(B)} &= \text{CF(3)} + \text{CF(A)} * [1 - \text{CF(3)}] \\ &= 0.8 + 0.4368 * [1 - 0.8] \\ &= 0.88736 \end{aligned}$$

2. D3 / Upas Mushroom (Upasia Salmonicolor)

$$\begin{aligned} \text{Cfcombine CF(A)} &= \text{CF(1)} + \text{CF(2)} * [1 - \text{CF(1)}] \\ &= 0.24 + 0.48 * [1 - 0.24] \\ &= 0.6048 \end{aligned}$$

From the manual calculations carried out above, the certainty factor value obtained for the symptoms indicating Coffee Leaf Rust (Himeleia Vastatrix) disease is 0.88736. From this value, the certainty value can be calculated as 0.88726 x 100% = 89%.

Interface implementation

The diagnostics page is designed to begin identifying coffee plant diseases. Users will be given a brief explanation regarding the answer choices in the select input which explains the value of certainty regarding the symptoms shown by coffee plants. Each symptom is linked to a list of possible coffee plant diseases based on the user's answers. Users select their confidence level, and by pressing the "Start Diagnostic" button, the system will begin calculations to make a final diagnosis based on user input. This page aims to provide a clear and intuitive interface in the process of identifying coffee plant diseases using the Certainty Factor method. Figure 1 displays an illustration of the page dedicated to disease detection.

The diagnosis results page displays the symptoms selected by the user and the Certainty Factor (CF) value which reflects the system's level of certainty regarding the relationship between symptoms and disease. The disease diagnosis results can be seen in Figure 2,

supported by a brief explanation of CF calculations for user understanding. In the conclusion section, information on selected diseases based on the highest CF value is accompanied by recommended solutions to overcome the identified coffee plant health problems. This page provides users with a comprehensive overview of the diagnostic results and actions that can be taken based on the information provided by the system.

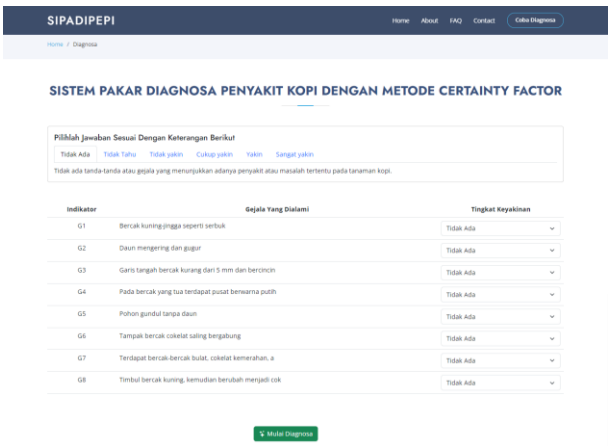

Figure 1. Disease detection page

Figure 2. Diagnostic results page selected symptoms section

System testing result

The Black Box testing method is testing that is more focused on the specifications of the module or functions being developed, both in terms of data structure, GUI errors, accessing data in the database, and performance errors [13]. The following are the test results:

1. Blackbox alpha testing

Functional testing uses Alpha blackbox. Alpha testing is a step carried out to verify optimal performance and the absence of errors or bugs in the application being tested [14]. The conclusion from the black box testing results is that the system runs well as expected.

2. Blackbox beta testing

Beta testing occurs subsequent to alpha testing and serves as a type of external user acceptance evaluation [15]. Based on the beta testing results, it was determined that the system developed met the expected requirements. This test was carried out by asking questions to 10 coffee farmers who acted as users, so the percentages could be determined as follows:

Percentage = Total score / Highest score x 100%
= 435/500 x 100%
= 87%

From the results of the tests carried out, an average percentage of 87% was obtained. From the information presented, one can infer that the diagnostic system evaluated in this research satisfies the requirements and is highly appropriate for farmers to diagnose diseases in coffee.

Conclusion

Based on the implementation of Certainty Factor (CF) in the coffee plant disease diagnosis system, this research succeeded in designing and testing an application using the Black Box Alpha and Beta methods. The Black Box Alpha test results show that the application runs well without significant errors and bugs. Beta testing involved the participation of 10 farmers as external users, and the results reached a percentage of 87%. This indicates that the coffee plant disease diagnosis system has successfully met the expected criteria. With the Certainty Factor-based diagnosis method, this application provides diagnosis results and recommended solutions based on the level of certainty of the relationship between symptoms and disease, helping farmers identify and overcome coffee plant health problems effectively.

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