Expert System for Diagnosing Palm Tree Diseases and Pests using Forward Chaining and Certainty Factor

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Abstract

A general introduction to pests and diseases of palm oil crops in relation with the business of palm oil cultivation is necessary to increase the productivity of palm oil plantations. Unfortunately, the number of experts and researchers having expertise in palm oil plants are still very small. To overcome this, an expert system is needed to diagnose diseases and pests in palm oil crops. Therefore, this study proposes an expert system for diagnosing palm tree diseases and pests. The diagnosis begins by entering the initial symptoms, then the system will display other related symptoms. Finally, the system will display the diagnosis of the symptoms entered. This expert system will ease farmers in identifying diseases and pests based on early symptoms; hence, necessary prevention and early treatment of the disease can be accurately conducted.

Keywords: *Expert System, Forward Chaining, Certainty Factor, Palm Tree Diseases and Pests*

1. Introduction

Palm oil plant (Elaeis Guinensis) comes from Nigeria, West Africa. In fact, palm oil plantations are fertile outside their home areas, such as in Malaysia, Indonesia, Thailand and Papua New Guinea. In Indonesia, palm oil plantations have important significance for the development of national plantations. In addition to provide employment opportunities leading to improving social welfare, it has been a source of state's foreign exchange [1].

The development of palm oil as an export commodity has steadily increased from year to year, it can be seen from the average growth rate of vast palm oil acreage during 2004-2014 accounted by 7.67%, and the production of palm oil has increased by an average of 11.09% per year [2]. The vast increment in the acreage driven by the prices of CPO (Crude Palm Oil) has relatively remained stable in the international markets and provided significant income to producers and particularly smallholders. These data suggest that the number of palm oil plantations in Indonesia each year has inclined.

To increase the productivity of palm oil plantations, the introduction of pests and diseases of palm oil plants regarding palm oil cultivation is generally necessary. Unfortunately, there is limited number of experts and researchers in palm oil plants. Conclusively, an expert system is needed to diagnose diseases and pests on palm oil crops. By establishing this expert system, farmers will be able to identify diseases and pests based on their symptoms as well as to provide early prevention and handling.

Expert systems in disease identification have already existed, for example in different sectors related to chicken farming [3]. The expert system identifies chicken diseases based on the symptoms generated using Certainty Factor method. This method has been used to determine the value of certainty and utilized in Forward Chaining possessing information ranging from base knowledge into expected conclusions. Forward Chaining starts the searching process with data so that this strategy is also called data-driven and considered as suitable for this case. Another related study employing Certainty Factor method examines the diagnosis of whether a patient suffers from diabetes nephropathy or not, generally minimizing the risks of errors in the process of diagnosis [4]. In addition, another relevant research aims to diagnose childhood illness using Certainty Factor method. The mechanism of this system is started by entering the symptoms to be diagnosed by the users; afterwards, the system will diagnose and calculate the weight value of each symptom. The results given by this expert system has met the purpose of the system to diagnose childhood illness. However, this expert system will be optimal if one in this case of child pediatrician has clearly defined the Certainty Factor value of each disease symptom against possible childhood illness [5].

Based on the previous research, Certainty Factor and Forward Chaining can be applied in the expert system diagnosis of palm oil pests and diseases due to the symptom characteristics of the disease and its similarity in the nature of the object. It is expected that the results obtained by the expert system utilizing a Certainty Factor and Forward Chaining can deliver the results required in the weighted calculation in the diagnosis conclusion.

2. Research Method

This study aims to optimize the diagnosis results of palm tree diseases by using Forward Chaining and Certainty Factor. To achieve these results, appropriate research methods will be applied in this study. Figure 1 shows an overview of the research methods employed in this study.
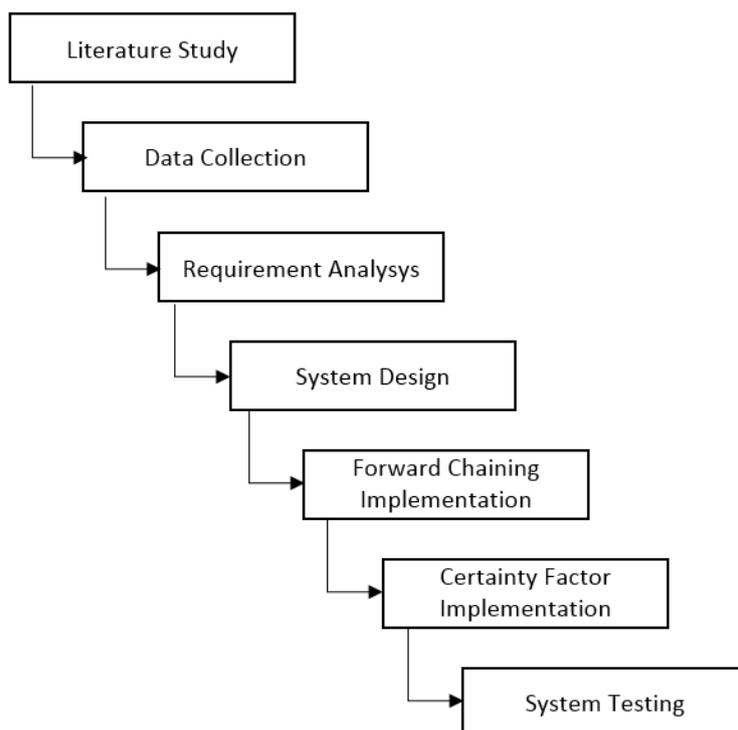

Figure 1. Research Method

2.1 Literature Study

The study of literature becomes an important process in obtaining relevant references and searching for desired methods. These references are closely linked to the topic of palm tree diseases, Forward Chaining method, and Certainty Factor method.

2.2 Data Collection

The data were obtained from the questionnaires to some lecturers in Plantation Cultivation Study Program in Hasnur Polytechnic and the experts in Hasnur Cipta Terpadu Inc. Thus, the weighted criteria for each symptom of palm oil disease could be determined. In addition to the given questionnaires, the data were also gathered through literature studies to collect information related to diseases and symptoms in palm oil plants, relevant methods, and other necessary knowledge in this study.

The use of questionnaire in this study aims to determine the weighted magnitude for each symptom in a specific disease. This is necessary in the determination of certainty on the Certainty Factor method. Questionnaires were distributed to a number of lecturers in the Plantation Cultivation Study Program in Hasnur Polytechnic considered having adequate and important experiences in the field of palm oil. The results were obtained in the form of a certainty that would be processed in the form of weighted Certainty Factor.

Palm oil diseases and pests have various types. Each type has multiple symptoms. Table 1 presentstypes of diseases and pests that could be identified in this system.

Table 1. Diseases and Pests of Palm Tree [6][7]

No.	Disease/Pest	Variety
1	Beetle	Pest
2	Nematodes	Pest
3	Caterpillar Fire	Pest
4	Caterpillar Bug	Pest
5	Mouse	Pest
6	Locusts	Pest
7	Mite	Pest
8	Moth	Pest
9	Growing Point Disease	Disease
10	Bud Rot Disease	Disease
11	Upper Stem Disease	Disease
12	Base Stem Rot Disease	Disease
13	Base Stem Dry Rot Disease	Disease
14	Root Disease	Disease
15	Anthracnose Disease	Disease
16	Yellow Line Disease	Disease
17	Headache Disease	Disease
18	Bunches Rot Disease	Disease

2.3 Requirement Analysys

At this stage, the analysis took from on the collected information about necessary materials being able to support the process of developing the program. After getting the required information; subsequently, all prerequisites were analyzed and defined to complete the system. This phase found functional and non-functional requirements.

2.4 System Design

The design was developed after reaching complete definition of the prerequisites from the previous phase. Afterwards, a flow chart diagram was created to have better organization presented in Figure 2.

2.5 Forward Chaining Implementation

Forward Chaining is one of the inference engines. Forward Chaining uses condition-action rule. In this method, the data used to determine which rules will be executed; consecutively, the rule will be executed. The process will be repeated until it an outcome has been located.

The use of the Forward Chaining on expert system will be presented in the following section [8].

Rule 1:
If the premise 1
And the premise 2
And the premise 3
Then the conclusion 1

Rule 2:
If the premise 1
And the premise 3
And the premise 4
Then the conclusion 2

Rule 3:
If the premise 2
And the premise 3
And the premise 5
Then the conclusion 3

Rule 4:
If the premise 1
And the premise 4
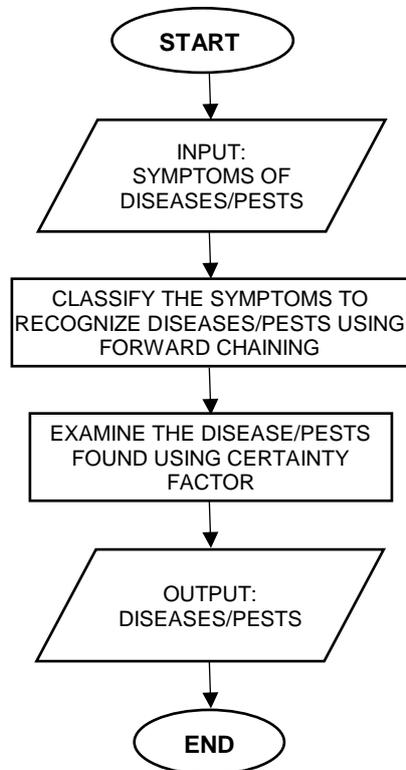And the premise 5
And the premise 6
Then the conclusion 4

Figure 2. Flowchart of the System

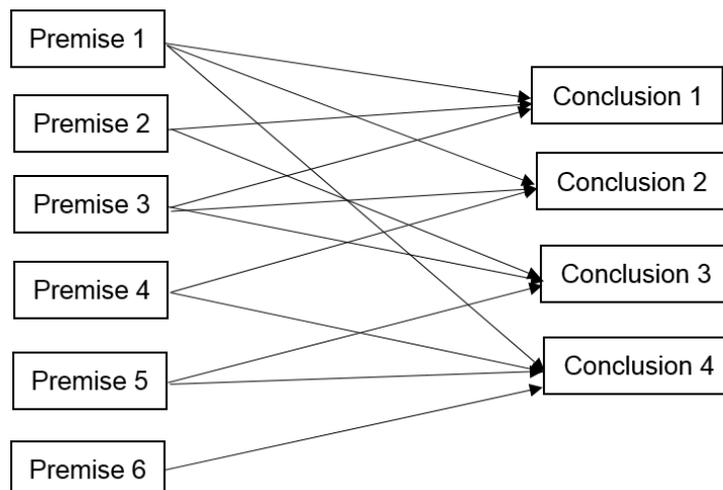The following Figure 3 illustrates these rules.

Figure 3. Forward Chaining Map

The user enters the premises from the list displayed by the system. Based on the selected premises, the system will search for the appropriate rules; afterwards conclusions can be retrieved.

For example, the user selects premise 1 premise 2 and premise 3 then the selected rule is rule 1 with its conclusion is the conclusion 1.

2.6 Certainty Factor Implementation

Certainty Factor was introduced by Shortliffe Buchanan in the manufacture of MYCIN. Certainty Factor is a clinical parameter values given to MYCIN to indicate the magnitude of the trust.

There are two kinds of weighting factor of certainty that can be employed namely:
1. Certainty Factor entered directly by experts.
2. Certainty Factor entered by users.
The formula [9] for determining weighted symptoms by Certainty Factor is defined in Equation 1.

$$CF(H,E) = MB(H,E) - MD(H,E) \qquad (1)$$

Notation:
CF(H,E)   :   Certainty Factor of hypothesis H is influenced by symptom (evidence) E. Magnitude Certainty Factor ranges between -1 to 1. A value of -1 indicates absolute distrust.
MB(H,E)   :   The measure of increased belief on hypothesis H is influenced by the symptoms E.
MD(H,E)   :   The measure of increased distrust (disbelief) to hypothesis H is influenced by the symptoms E.

An expert system often has more than one symptom and consists of several premises connected by AND or OR. Certainty Factor formulas for some of the symptoms leading to the same hypothesis, and Certainty Factor combinations can be written as follows [8]. If CF(x) > 0 and CF(y) > 0, it uses Equation 2. If CF(x) < 0 and CF(y) < 0, it uses Equation 3. If one of (CF(x), CF(y)) < 0, it uses Equation 4.

$$CF(H) = CF(x) + CF(y) - [CF(x) * CF(y)] \qquad (2)$$

$$CF(H) = CFx + [CF(y) * (1 - CF(y))] \qquad (3)$$

$$CF(H) = \frac{CF(x) + CF(y)}{(1 - (\min(|CF(x)|, |CF(y)|)))} \qquad (4)$$

Table 2 shows the value of moth pest symptoms using Certainty Factor, calculated as below. Based on the previous calculations, the Certainty Factor of Moth Pest is 0.96 or 96%.

Table 2. Certainty Factor Calculation of Moth Pest

No.	Symptom	Disease/Pest	CF
1	Leaves Rolling	Moth	0,6
2	Leaves Grow Upright	Moth	0,6
3	Yellow Leaves	Moth	0,8

CF (A) = CF (1) + CF (2)-[CF (1) * CF (2)]
          = 0.6 + 0.6-[0.6 * 0.6]
          = 0.84

CF (B) = CF (3) + CF (A)-[CF (3) * CF (A)]
          = 0.8 + 0.98-[0.8 * 0.98]
          = 0.96

On a system that has been established in this research, the weighting factor of the assurance was directly obtained from the experts to be combined by Certainty Factor calculation. The weights were obtained by question forms given to experts of plant palm oil.

2.7 System Testing

System testing aims to determine the results of the developed system. The test method used is using Precision and Recall method [10]. The Precision method measures the level of accuracy between the information requested by the users and the answers given by the system. While the Recall method measures the success rate of the system in rediscovering information.

3. Result and Discussion

3.1 Diagnosis Phase of Diseases and Pests

The system starts from the data initialization for disease symptoms and then displayed on the system. The user enters the symptoms then if there are additional symptoms; they will be reinserted until all symptoms are completely inputted. Furthermore, the system searches for related diseases using Forward Chaining.

The diseases discovered using Forward Chaining method will be grouped symptoms and the disease to the calculation of Certainty Factor joint. This calculation aims to find diseases that have the highest certainty. In the calculation, Certainty Factor is calculated based on the CF (x) and CF (y).

After the calculation is performed, then the calculation result will be displayed based on the Certainty Factor. The data show the results of diagnosis and ways to combat the disease.

3.2 Experiment

The testing was executed by comparing the results of expert system to the obtained information from experts. The experts were lecturers from Plantation Cultivation Study having expertise on palm trees. An experimental scenario to show the system was able to search the specific diseases or pests can be established. Afterwards, Two Information Retrieval (IR) standards: Precision and Recall as the performance metrics were implemented. Table 3 shows the results of the comparison of expert system and obtained information from experts.

4. Conclusion

This expert system application can be well operated and is advised to be applied. Based on the results obtained from the tests using Precision and Recall, the system, conclusively, is almost identical with the diagnosis of diseases and pests, showing the precision value of 90% and recall value of 50%.

This expert system can be analyzed and developed further as good as MB and MD for the calculation of Certainty Factor. Dynamicization and interferences in the knowledge or diagnostic data such as data on symptoms, diseases, and other solutions can be developed further.

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Table 3. Testing Results

No	Input	Result	Description
1	**Early Symptoms:** Existing holes in leaves **Advanced Symptoms:** Damaged young leaves, biting remnants on leaves	Beetle	Relevant
2	**Early Symptoms:** Yellow colored leaves **Advanced Symptoms:** -	Nematodes	Irrelevant
3	**Early Symptoms:** Chocolate brown colored leaves **Advanced Symptoms:** Nets on rotten buds	Rotten buds	Relevant
4	**Early Symptoms:** Fragile buds **Advanced Symptoms:** Rotten buds Rotten smell	Rotten Growing Point	Relevant
5	**Early Symptoms:** Damaged middle leaves **Advanced Symptoms:** Abnormal offspring size	Crown	Relevant
6	**Early Symptoms:** Mycelium (fungi) in the ripe fruits **Advanced Symptoms:** Mycelium at the base of the fruits	Rotten Bunches	Relevant
7	**Early Symptoms:** Yellow leaves **Advanced Symptoms:** Abnormal growth, crops not fresh	Root	Relevant
8	**Early Symptoms:** Biting marks in the fruits **Advanced Symptoms:** Existing dirt	Mouse	Relevant
9	**Early Symptoms:** Holes in leaves **Advanced Symptoms:** Biting marks	Locusts	Relevant
10	**Early Symptoms:** Holes in leaves **Advanced Symptoms:** Dead plant	Caterpillar Fire	Relevant

Table 3 presents the Precision values and the Recall values.

$$Precision = \frac{Relevant\ Number\ of\ Diseases}{Number\ of\ Diseases}$$

$$Precision = 90\%$$

$$Recall = \frac{Relevant\ Number\ of\ Diseases}{Total\ Number\ of\ Diseases}$$

$$Recall = 50\%$$