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Use of an certainty factor method for diagnosing disease in plantation crops with economic value

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Abstract

This paper outlines an alternative solution to help Indonesian farmers in diagnosing diseases in plants. One solution is to create an expert system application that can diagnose diseases in plants of economic value using a certainty factor for search solutions. This research uses a knowledge base for the diseases that attack plantation crops such as coffee, cocoa, pepper, nutmeg, and coconut. These types of plants are the most frequently cultivated on Indonesian plantations and possess high economic value. This research aims to help improve farmers' knowledge with regard to diagnosing diseases in plants with high economic value. Based on tests given to farmers, this application was shown to have increased their knowledge with regard to diagnosing diseases in plantation crops with economic value through the use of a certainty factor method. This research resulted in the creation of software that can diagnose 36 different diseases in plants by applying the certainty factor method. Based on testing conducted to measure farmers' level of understanding with regard to diagnosing diseases in plants, we found that traffic increased on average of 21.8 to 35.9 after using the expert system application.

Keywords: Certainty factor, Expert system, Plantation crops

1. Introduction

Indonesia is a rich in flora, and the climate is suitable for the growing of various types of crops. Plantation crops are one type of prospective plant with high economic value. Plantation crops have an important role in economic development in Indonesia, as they can potentially lead to more international trade, create jobs, become a source of income for the population, and to contribute to efforts to preserve the environment. In addition, products of plantation cultivation can be exported or used domestically as industrial raw materials. There are more than 100 types of commodities that can be developed in Indonesia, and the plantation crops that have the highest economic value and help improve the lives of those living in Indonesia are clove, chocolate (cocoa), cotton, cinnamon, rubber, coconut, coconut oil, hazelnut, coffee, pepper, nutmeg, sugarcane, tea, tobacco, and vanilla [1 - 4].

Surveys conducted in the Farmers Group Tunggak Semi, an association for coffee and cacao (chocolate) farmers in village Pentingsari Umbulharjo, Cangkringan, Sleman, Yogyakarta-Indonesia found that the average farmer's knowledge of diseases in perennial crops was limited to common diseases, such as rotten root, twig borers, root fungus, and leaf rust. The farmers claimed that the difficulty in identifying new diseases in perennial crops was due to limited availability of information, which came only from books or counseling. Moreover, due to time restraints, there is a limited amount of agricultural counseling that can be conducted in each region.

Because of these problems, there needs to be an alternative solution for farmers for identifying diseases in plantation crops in order to reduce the risk of crop failure and to increase crop production. One alternative solution is to create a consultation media acted as an expert, which are called expert systems. This study aims to create an expert system application for diagnosing diseases in plantation crops.

2. Materials and Methods

This expert system application, which is aimed at diagnosing diseases in plantation crops with high economic value, is a web-based application, developed using PHP programming language. The data regarding plantation diseases were retrieved from the Department of Agriculture and Forestry in 2015 and 2016. The waterfall model was used in the development of the software. The reason for using a certainty factor for obtaining certainty in tracking solutions is that knowledge related to symptoms may be applicable in various diseases. By using a CF combination method, it is possible to track plant diseases with similar symptoms. Farmers' level of understanding with regard to disease diagnosis in plants was analyzed using parametric statistical concepts with test T (T Test).The steps are shown in Figure 1.

3. Results

A solution-searching process using the forward-chaining method was implemented during the consultation process. Two types of certainty values were used in the consultation process: the certainty value from the user/farmer and the certainty value from the plantation expert, both of which were stored in the rule base. Certainty Factor (CF) was the process used to obtain the certainty values.

The expert systems that were products of this research were tested on the farmers. System testing was conducted in two ways: 1) the farmer is given questionnaires related to knowledge of the disease without the use of an expert system application, and 2) farmers are given a questionnaire using an expert system application. According to the test results, there is an average difference in farmers' knowledge of 21, 80 into 35,90. Thus the ability of farmers in diagnosing diseases in plants rose by 14,1.

This research produced software to be used as consultation media for farmers in diagnosing diseases in their plants. The application that was developed uses expert system concepts with a forward-chaining solution searching model supported by certainty factor value. To use this application, users first need to log in. There are three different types of user accounts, namely, Plantation expert, Farmer, and Government employee (in this case, employees of the Department of Forestry and Agriculture). These users have different access rights. The business process related to the usage of this application is shown in Figure 2.

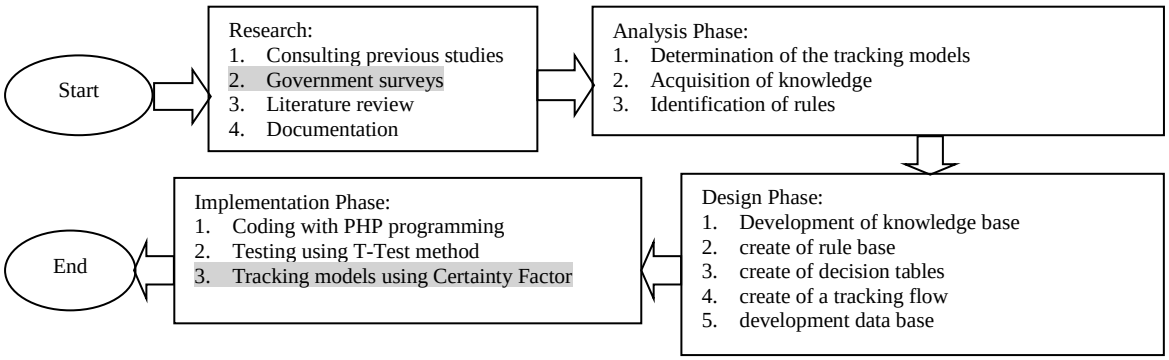

Figure 1 Research methodology

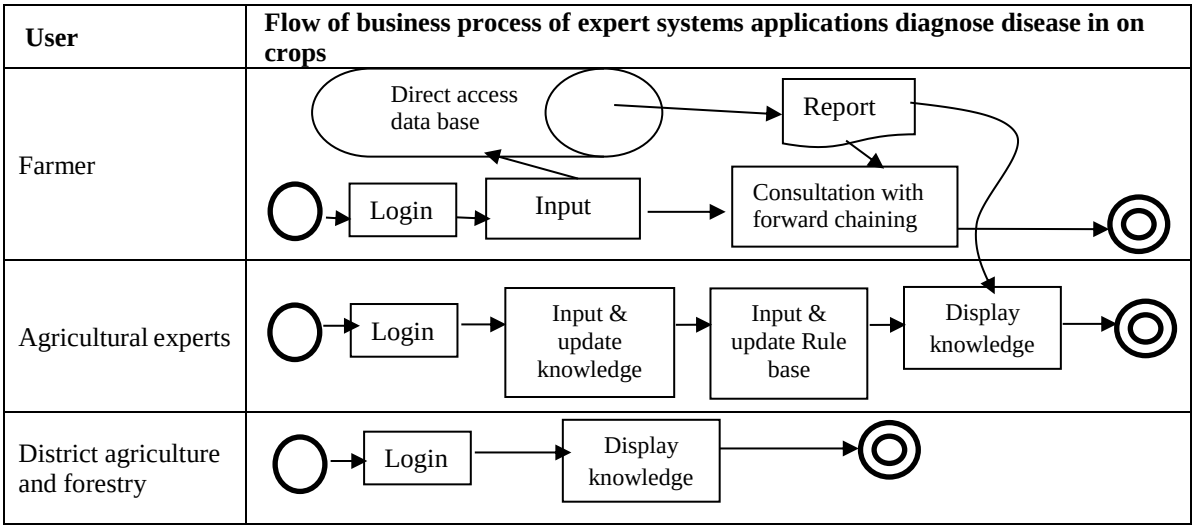

Figure 2 Flow of business process of expert system applications diagnose disease in on crops

Table 1 Sample of diseases and symptoms in coffee plants using a certainty factor

Symptom	Symptom code	MB	MD
Leaves have s pale or dark yellow splotches	G001	0.7	0.3
Loss of leaves	G002	0.6	0.4
Overproducing of fruit	G003	0.7	0.3

4. Discussion

There are several publications that have discussed certainty factors [6 - 8]. One paper, for example, discussed the implementation of an expert lending system using the Certainty Factor method [6]. The expert system implemented in this report takes advantage of expertise in the area of granting loans to build a knowledge base. The system helps in making evaluations and expediting activities. Furthermore, using this system, accuracy is improved, allowing managers to trust expert decisions in granting or rejecting loan requests with more confidence. The proposed system uses a certainty factor to determine the characteristics of the case and ultimately helps managers make better decisions. Another paper reported on the implementation of a certainty factor used in expert systems in the Comparison Model for Uncertain Information [7]. This paper reviews some of the literature on uncertainty management in order to highlight, compare, and clarify the differences among these approaches in terms of the application and target problem-solving areas. With this, we propose a comparison model which can serve as a guide in selecting a suitable uncertainty-management approach that considers three uncertain information categories: event, evidence, and variable. These three categories are different in terms of their area of problem solving.

The expert system was tested before developing the application to diagnose diseases in plantation crops. The testing process was conducted to obtain validation from the users regarding the implementation of the disease-tracking process. Case testing was performed in order to implement the certainty factor method. Analysis of cases using certainty factor method is described below. Suppose users input symptoms experienced on the plants as shown in Table 1.

Description
CF is the certainty factor in the hypothesis H due to evidence E
MB is the measure of increased belief in H due to E
MD is the measure of increased disbelief in H due to E
Using the 1st formula: $CF[h,e_1]=MB[h,e_1] - MD[h,e_1]$ and
the 2nd formula for CF combination value : $MB[h,e_1 \wedge e_2] = \{MB[h,e_1] + MB\ h,e_2\}*(1-MB[h,e_1])\}$, CF calculation illustration is as shown in Table 2 [9, 10].
Based on Table 2, from the symptoms input by the user, the greatest certainty value for Leaf Rust Disease is 0.37 according to the CF calculation (P001 code). As both the application and manual calculation yielded the same result, it can be concluded that the application calculation was correct.
The application was tested in the 10 respondent farmers, and significant differences were found with regard to farmers' knowledge of diseases in plants. This data was reinforced by the results of tests performed to test the farmers' knowledge before and after the application was built. The results shoed that the farmers' knowledge had increased an average of 60.7. Before using the app farmers average ability - was 21.8, whereas after using the app it rose to 35.9. Detailed test results can be seen in Table 3.

Table 2 Searching using the certainty factor method

Code of symptom	Code of disease	Symptom	CF values
G001, G002, G003	P001	Preliminary calculations for the symptoms G001 [h,e_1] CF[h,e_1]=MB[h,e_1] - MD[h,e_1] =0.7 – 0.3 = 0.4	0.4
	P001	New symptom G002 [h,e_2] Initial calculation for G001 [h,e_2] CF[h,e_2]=MB[h,e_1] - MD[h,e_1] =0.6 – 0.4 = 0.2 Calculation of the second symptom (and further) using MB and MD values. Result of calculation on Symptom G001 and G002: MB[h,e_1^e_2]={MB[h,e_1]+MBh,e_2]*(1-MB[h,e_1])} ={0.7 + ((0.6*(1-0.7))} =0.7 + 0.18 = 0.88 MD[h,e_1^e_2]={MD[h,e_1]+MDh,e_2]*(1-MD[h,e_1])} ={ 0.3 + ((0.3)*(1-0.3))} =0.3 + 0.21 = 0.51 CF[h,e_1^e_2] = MB[h,e_1^e_2] - MD[h,e_1^e_2] =0.88 – 0.51 = 0.37	0.37
	P001	third symptom is inputted G003 [h,e_3] CF[h,e_3]=MB[h,e_3] - MD[h,e_3] =0.7 – 0.3 = 0.4 Calculation of the third symptom G001^G002 dan G003 MB[h,(e_1^e_2)^e_3]={MB[h,e_1^e_2]+MB [h,e_3]*(1-MB [h,e_1^e_2])} = {0.88 + ((0.7*(1-0.88))} = 0.88 + 0.084 = 0.964 MD[h,(e_1^e_2)^e_3]={MD[h,e_1^e_2]+MD [h,e_3]*(1-MD[h,e_1^e_2])} ={ 0.51 + ((0.3)*(1-0.51))} =0.51 + 0.147 = 0.657 CF[h,(e_1^e_2)^e_3] =MB[h,(e_1^e_2)^e_3]-MD[h,(e_1^e_2)^e_3] = 0.964 – 0.657 = 0.307	0.307

Table 3 The measurement of farmers' understanding of disease diagnosis by the application expert systems

Respondents (farmers)	Results of data collection knowledge of farmers before using the application that utilized the certainty factor for diagnosing disease in crops with economic value	Results of data collection with regard to farmers' knowledge after using the application that utilized the certainty factor for diagnosing disease in crops with economic value
1	20	37
2	21	34
3	21	37
4	21	35
5	23	36
6	22	37
7	25	36
8	22	35
9	21	35
10	22	37
Total	218	359
Average	21,80	35,90

5. Conclusions

Based on this study, it can be concluded that the certainty factor method can be implemented in an expert system application to diagnose disease in plantation crops. In this study, it was tested for five types of plants, namely; Chocolate (cocoa), nutmeg, coffee, pepper, and coconut. All of these plants have high economic value in Indonesia. Results of tests that were performed on farmers proved that this application can increase farmers' knowledge after use of the certainty factor method for diagnosing disease in plantation crops with economic value. This can be seen in the improvements in farmers' test results. After use of the application, farmers had an average score of 35.9, whereas before, they had an average score of 21.8. Another conclusion of this research is that the implementation of tracking methods using a certainty factor can be applied to the application of expert systems to diagnose diseases in crops of high economic value. This is because the knowledge gained includes symptoms related to diseases in five types of plants, namely, Chocolate (cocoa), nutmeg, coffee, pepper, and coconut.

6. Acknowledgements

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