

Expert System Model for Identification Pests and Diseases of Forest Tree Plantations

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Abstract

Various pests and diseases which are a disturbance in a forest plantation widely reported by many practitioners and researchers in forest management. Therefore, pests and diseases management activities become a very important part in the management of forest plantation. As an important stages in forest management, identification and recognition by an expert should be done quickly and accurately, moreover the proper handling also become an important step. In research area of artificial intelligence, known expert system, it could be as an alternative solutions to be one of forest management tool. This research aims to propose an expert system model that used for several tree plantations. It model consists of an architecture of expert system, inference method, several alternative of certainty and uncertainty methods, knowledge base, and also view of Graphical User Interface (GUI) for user's interactions. The important team in the expert system development, they are project manager, domain expert, knowledge engineer, programmer, system analyst, and end-users.

Keywords: *Expert system, forest plantation, artificial intelligence, forest management tool.*

1 Introduction

Pests and diseases associated with disturbance as global issues in a forest plantation widely reported by many practitioners and researchers in several trees, including *Pinus merkusii* [1], *Acacia mangium*[2], *Tectona grandis*[3], Holm oak[4], *Falcataria moluccana* [5], and *Pice pungens* [6]. Homogeneous and extensive as a model forest plantations, favor insect pests and diseases to spread rapidly [7], [8]. Therefore, pests and diseases management activities become a

very important part in the management of forest plantation. As an important stages in forest management, identification and recognition [9] by an expert should be done quickly and accurately, moreover the proper handling also become an important step.

As a branch of artificial intelligence [10], [11], expert system is an application software that employs human knowledge captured in a computer to solve the specific problems are needed human expertise [12] as an alternative solutions to be one of forest management tools. This research aims to propose an expert system model that used for several trees plantation.

A few studies related to this work has been done by other researchers, including proposed an expert system framework for managing crop pest and diseases[13]. It research focuses on to identify and explain trends of methodologies used by previous works. As a result, Ref. [13] proposed a conceptual framework for managing crop pest and disease.

Nascimento et.al develop an expert system as an appropriate technology to identify 23 insects in commercial teak plantations [7]. The identification of insects species to the species level used for making decision on control. Users can get some information about insects after process identification in screen showing on mobile application, including its scientific name, taxonomic group, species description, damage characteristic, geographic distribution, references, and more pictures of the causal agent. More than that, the user can observe the insect causing the injury, answer the questions, and view images, increasing the final accuracy of diagnosis. Kaloudis et.al. develop an expert system for identified insect for an alternative way to forest protection activities [14].

Different with others researchers, this research will be described a model of Expert System for identification pests and diseases in several forest plantation. The model included an extended expert system architecture, knowledge base design, and a recommended certainty and uncertainty method.

2 Material and Method

Based on data acquisition conducted in 2013-2014, obtained information pests and disease that attacked *Tectona grandis*, *Falcataria moluccana*, *Pinus merkusii*, and *Acacia mangium*. Table 1 shows the sample data of pest and diseases on various plantations.

The data acquisition has been done by observation in forest plantations, material and research results at Lab of forest health and protection of University of Gadjah Mada, books collection, and surfing related reference over the internet including e-book, journal article, conference proceedings, web page, working paper, and report.

To design an architecture of expert system modified and referred to Turban et. al. [15] with a viewpoint of players in the development team of expert system that

modified from [16], including : 1) project manager, 2) domain expert, 3) knowledge engineer, 4) programmer, 5) end-user, and 6) system analyst.

Table 1: Sample data of pests and diseases on *Falcataria moluccana* and *Acacia mangium*

<i>Pest</i>	<i>Disease</i>
<u>Falcataria moluccana</u>	<u>Falcataria moluccana</u>
<i>Amatissa sp.</i>	<i>Anthracnose</i>
<i>Coptotermes sp.</i>	<i>Cancer</i>
<i>Cryptothelea</i>	<i>Colletotrichum gloeosporioides (Penz.) Sacc.</i>
<i>Eucophila rorida</i>	<i>Damping off</i>
<i>Epidota stigma</i>	<i>Gall rust</i>
<i>Eurema spp.</i>	<i>Mead</i>
<i>Hyposidra talaca Walker</i>	<i>Powdery mildew</i>
<i>Indarbela acutistriata</i>	<i>Root rot</i>
<i>Macrotermes gilvus</i>	<i>Sooty mold</i>
<i>Mahasena corbetti</i>	<i>Stem rot</i>
<i>Melionia basalis</i>	
<i>Olotrichia helleri</i>	<u>Acacia mangium</u>
<i>Planococcus citri</i>	<i>A new wilt and die-back disease</i>
<i>Pteroma plagiophelps</i>	<i>Atelocauda digitata</i>
<i>Psyche sp.</i>	<i>Botryosphaeria sp</i>
<i>Valanga nigricornis</i>	<i>Colletotrichum sp</i>
<i>Xystrocera festiva</i>	<i>Cyclindrocladium sp</i>
<i>Xystrocera globusa</i>	<i>Foliar spor</i>
<i>Zeuaera coffeae</i>	<i>Ganoderma spp</i>
	<i>Meliola spp</i>
<u>Acacia mangium</u>	<i>Oidium spp</i>
<i>Asian ambrosia beetle</i>	<i>Phomopsis foliar spot</i>
<i>Bagworm</i>	<i>Pink disease</i>
<i>Coffe borer</i>	<i>Phellinus noxius</i>
<i>Comma moth</i>	<i>Phytium spp,</i>
<i>Gold dust weevil</i>	<i>Phytophthora spp.</i>
<i>Noctuidae</i>	
<i>Tea mosquito bug</i>	

3 Results and Discussion

An expert system is a decision making computer package that reaches a level a comparable to a human expert in a specific area in expertise [15]. An architecture system is needed in developing an expert systems. Some methodologies, architectures, and applications of expert system has been published with several researches including Turban et. al. [15], Kaloudis et.al. [14], Shafinah et.al.[13], and also record of methodologies a decade review from 1995 to 2004 reported by Liao[11].

3.1 System architecture

The expert system typically comprises has two essential components, including a knowledge base that capturing the domain-specific knowledge, and an inference engine consisting of algorithms for manipulating the knowledge represented in the knowledge base [17]. Based on several researchers and our research since 2013 in this section we are proposed the architecture of expert system for identification pests and diseases on forest tree plantations (Fig. 1).

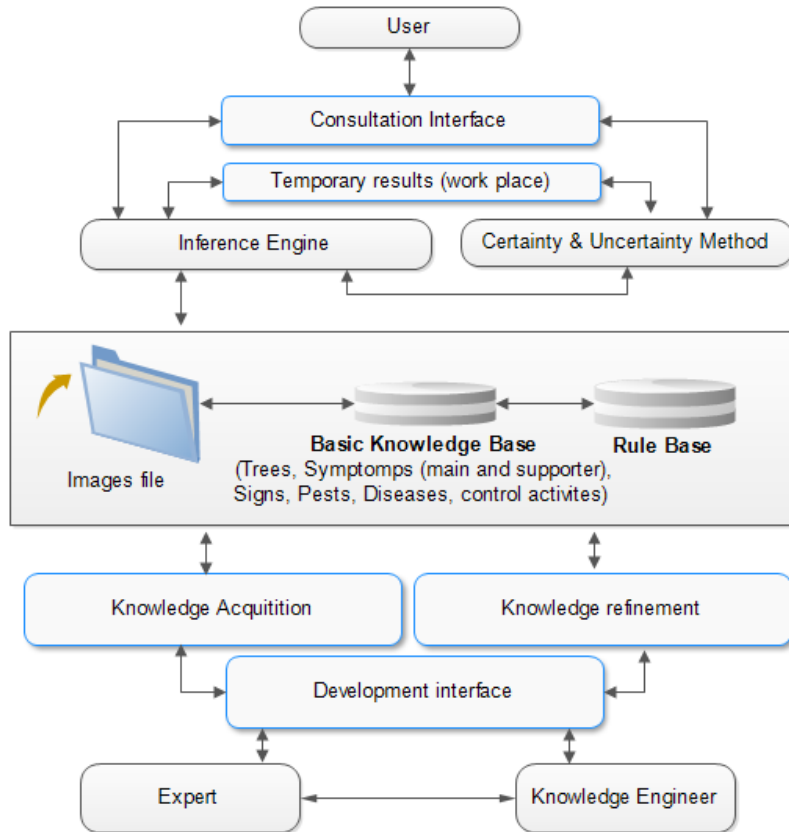


Figure 1. Expert system architecture

Inspired by Turban et.al. [15], the proposed expert system architecture can viewed on two sides, consists of consultation and development sides. The consultation side provided consultation interface to end-user for to do consultation with the expert system, inference engine, certainty and uncertainty method, and temporary results (work place). The end-user is requested and retrieved data from knowledge base and image files, and the expert system will be given a results based on the rule base using inference engine and certainty/uncertainty methods.

The development side have two users that interacting with the expert system, consists of an expert (domain expert), and knowledge engineer. An Expert is a person who have a knowledge that capable to solving problems in a specific area

or domain, a knowledge engineer is a person who captured a knowledge of expert to expert system. In this architecture, an expert and knowledge engineer were should be communicate each other in the expert system development, and they also could be accessed to expert system directly.

By using a development interface, an expert and knowledge engineer are have activities to make a knowledge representation in knowledge acquisition activities, and to do knowledge refinement if it needed.

3.2. Knowledge base

The knowledge base of the Expert System for identification of several forest tree plantation can describes as a relational database (Fig. 2), includes the information of trees, symptoms (main and supporter symptoms), signs, pests, diseases, control activities, set of rule based. The image files are save separately in a specific folder as an additional information in the consultation dialogue.

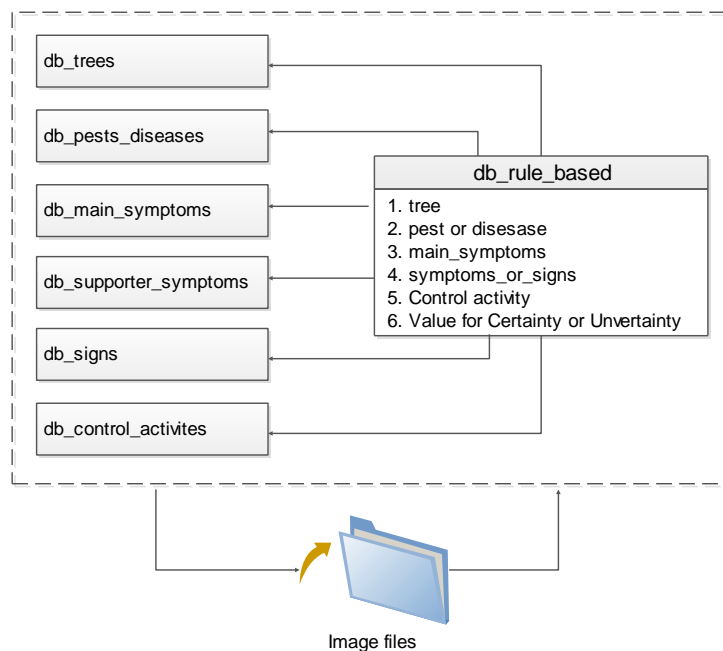


Figure 2. Knowledge base description

3.3. Inference Engine

Inference engine is one of important component on expert system, it alike a heart for an expert system[18]. It tracks for each rule to mining a knowledge in knowledge base. There are two approach how the inference engine works, forward chaining and backward chaining[19]. Forward chaining process an initial facts first, and using the rules to give the results or conclusions. Backward chaining

process based on the goal and then looking for the rules to prove the hypothesis. A simple example of rule based inference shows in Fig. 3.

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If symptom_1 AND symptom_2 AND symptom_n
  AND sign_1 AND sign_2 AND sign_n
THEN suggested_possible_pests_or_diseases
  
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Figure 3. Forward chaining inference engine

In our research, inferences engine (Fig. 4) was developed by combining a rule base inference engine and certainty/ uncertainty method. For the identification process, we used forward chaining method. Furthermore, the consultation process start from selected a main symptom, supporter symptoms, and signs by end-users. The rules will be used to given a possible suggestion of pests and/or diseases with fitted a certainty/uncertainty value for each alternative pests and/or diseases that showed in the results.

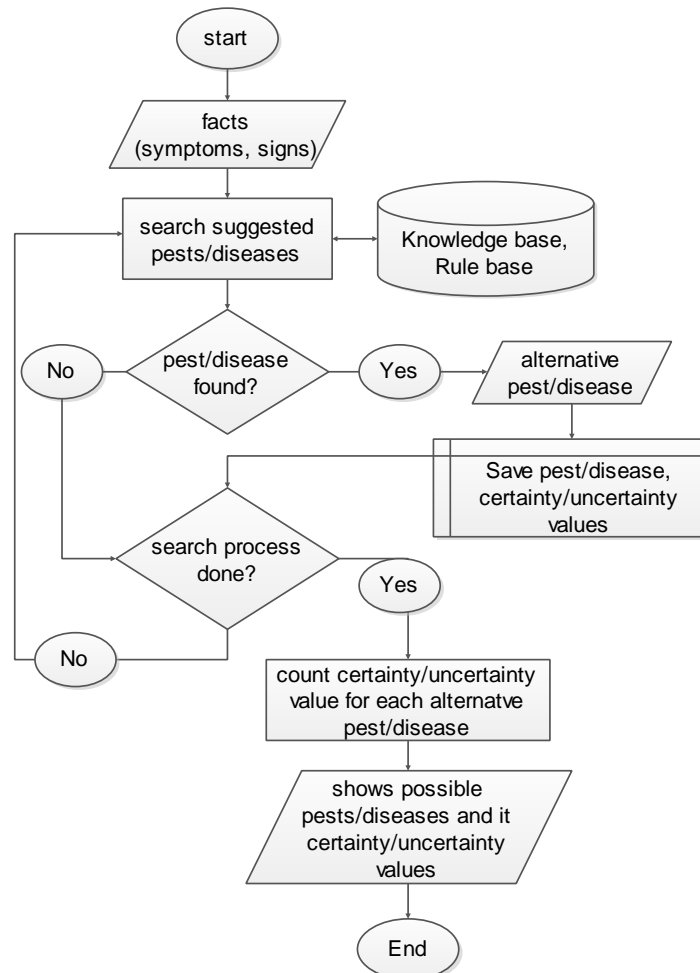


Figure 4. Inference engine

Fig. 4. shows the flowchart of inference engine process combining with certainty/uncertainty method. The engine will be searched an alternative pests and/or diseases at databases based on knowledge base and rule based, and then save them. The next process is counting certainty/uncertainty value for each alternative pests and/or diseases, and the last inference engine given pests and/or diseases and it certainty/uncertainty values.

The rule base and the domain declaration together constitute the knowledge base of the production system [17]. For the example, decision tree of leaf yellowing main-symptom (GU1) on *Falcataria moluccana* [20] that stored in databases shown in Fig. 5. Where, G1 (pale leaves), G5 (fallen leaves) and G10 (withered) are the supporter symptom; T1 (fruit body), T2 (mycelium) and T3 (spores) are the signs; P6 (root rot) and P7 (mead) are the pests/diseases.

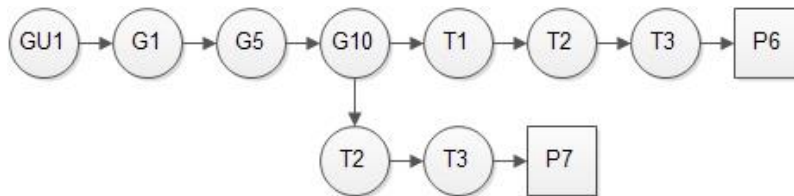


Figure 5. Decision tree of leaf yellowing main-symptom

When decision tree (Fig. 5) converted to a rule, it produces two rules with as an Expert-certainty value as in Fig. 6.

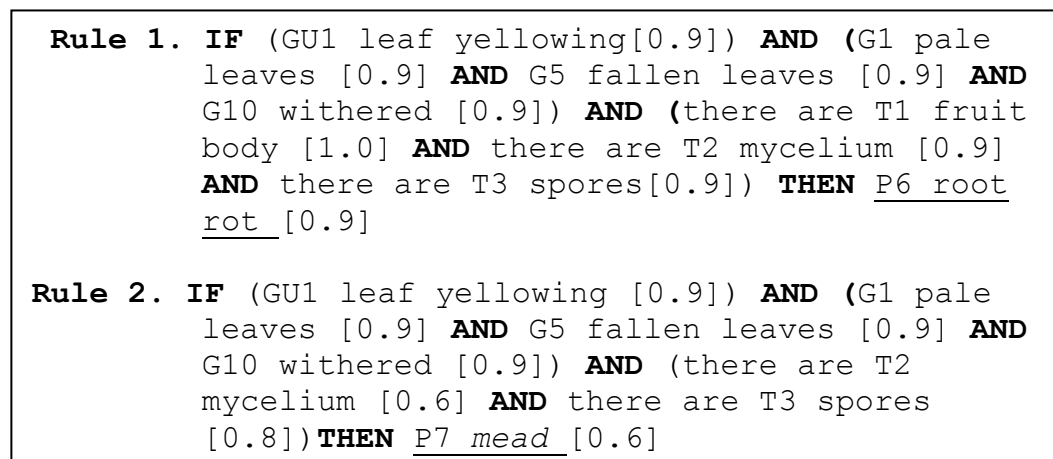


Figure 6. Rule based sample

3.4 Certainty and Uncertainty Methods

The earliest expert systems of the 1970s ignored uncertainty and used strict logical reasoning, but soon it became clear that this was impractical for most real-world domains. The next generation of expert systems (especially in medical

domains) used probabilistic techniques [10]. Some certainty and uncertainty methods were used by previous works, including certainty factor [21], Bayesian [19], [22]–[24], Dempster Shafer [25], [26], Classification and Regression Tree (CART) [27]–[30], Rough Set [31], [32], Discrete Wavelet Transform (DWT) - Adaptive Network Based Fuzzy Inference System (ANFIS) [33]. These certainty and uncertainty model could be chosen based on data availability.

Uncertainty in the development of expert systems can be caused by several factors, including incomplete information, different viewpoints of experts, and different impression language from the expert. Therefore, for uncertainty/certainty determination in one impression we consider to use three alternative approaches, there are linguistic, quantitative, and percentage (Table 1).

Table 1 Uncertainty/Certainty determination based on linguistic terms, quantitative value, and percentage

Linguistic term	quantitative value	Percentage
Definitely not	0	0
Almost certainly not	0.1	10
Probably not	0.2	20
Maybe not	0.3	30
Unknown	0.4 to 0.6	40 to 60
Maybe	0.7	70
Probably	0.8	80
Almost certainly	0.9	90
Definitely	1.0	100

During a consultation factual information can be represented in a number of ways, for the example the following facts including main symptom, supporter symptom, and signs with certainty value from the end user are typical elements of a fact set after a specific consultation (Fig. 7).

<u>Case 1</u>	
Main Symptom	: GU1 Leaf yellowing [1.0]
Supporter Symptoms	: G1 Pale leaves [1.0]; G10 withered [1.0]
Signs	: T2 mycelium [0.9]
<u>Case 2</u>	
Main Symptom	: GU1 Leaf yellowing [1.0]
Supporter Symptoms	: G1 Pale leaves [1.0]; G10 withered [1.0]
Signs	: T2 mycelium [0.9]; T1 fruit body [0.9]

Figure 7. Rule based sample

The rule base on Fig. 6 and the Facts on Fig. 7 can be processed by certainty/uncertainty methods. The results of an expert system calculated by certainty factor shown in Fig. 8. Fig. 8(a) shows that the case 1 results is two diseases, namely *Root rot* with certainty value is 81%, and *Mead* diseases with certainty value is 54%. Yet, in the case 2 added *fruit body* sign the results change to only *Root rot* diseases with certainty value 81%. The simulation shows the facts can be uncompleted, but with certainty/uncertainty methods the experts system still can be given the results complete with the certainty/uncertainty values. The used of certainty/uncertainty methods depend on data availability and the extent to which users can be involved in making the decisions. The expert system developer can use the values of certainty/uncertainty from only the expert, and another options is using the combination values certainty/uncertainty within end users and the experts to make some recommendation or conclusions.

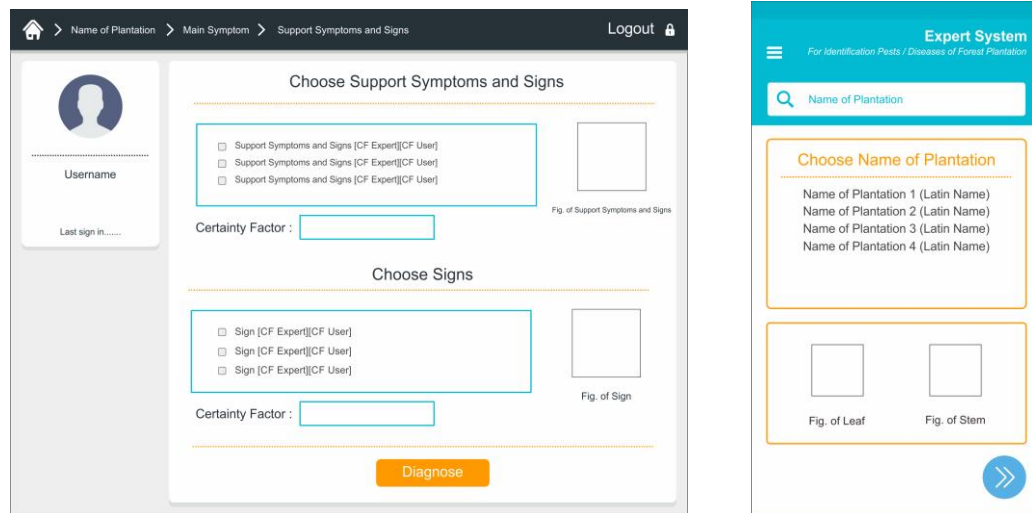


Figure 8. Screenshot inference engine results

3.5 System Interface

System interface is required by users for interaction with expert systems. End-user interactions with system by input the fact, and expert system process it with inference engine and give an answer or output in a language suitable for user to understand it [18]. In this system user interface divided into two functions, consists of 1) Consultation interface, and 2) development interface. The consultation interface is using by end-user to get a solutions or answers from a problems or questions. The development interface is using by an expert (domain expert) and knowledge engineer for developing activities including adding rules, knowledge base, and knowledge refinement. In the first development in the year of 2013-2014 (Fig. 7), we have developed an expert system with desktop based application. But, since 2015 we are migrate to web and mobile based applications Fig. 8. Web based application can used by expert (domain expert) and software engineer to do development activities, and for end-users to do consultations

activities. But, mobile based application only can use by end-user for consultation activities.



(a) Web based application

(b) mobile based application

Figure 9. Expert system application prototype

4 Conclusion

This research proposed an expert system model for identification pests and diseases of forest tree plantations, including an architecture of expert system, inference methods, several alternative of certainty and uncertainty methods, knowledge base, and also view of Graphical User Interface (GUI) for user's interactions. The team that included in the expert system development, they are project manager, domain expert, knowledge engineer, programmer, system analyst, and end-users.

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