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Forward Chaining Method on Diagnosis of Diseases and Pests Corn Crop

Nurlaeli[1,a)] and Subiyanto[2,b)]

[1,2]*Electrical Engineering Department, Engineering Faculty Universitas Negeri Semarang, Sekaran, Gunungpati, Semarang 50229, Indonesia*

[a)] Corresponding author: noor_liy@yahoo.com
[b)]subiyanto@mail.unnes.ac.id

Abstract. Integrated pest management should be done to control the explosion of plants pest and diseases due to climate change is uncertain. This paper is a present implementation of the forward chaining method in the diagnosis diseases and pests of corn crop to help farmers/ agricultural facilitators in getting knowledge about disease and pest corn crop. Forward chaining method as inference engine is used to get a disease/ pest that attacks the corn crop based on symptoms. The forward chaining method works based on the fact that there is to get a conclusion. Fact in this system derived from the symptoms of the selected user is matched with the premise on every rule in the knowledge base. A rule that matches the facts to be executed to be the conclusion in the form of diagnosis. This validation using 36 data test, 32 data showed the same diagnostic results between systems with an expert. So, the percentage accuracy of results of diagnosis using data test of 88%. Finally, it can be concluded that the diagnosis system of diseases and pests corn crop can be used to help farmers/ agricultural facilitators to diagnose diseases and pests corn crop.

INTRODUCTION

Corn as a staple food after rice in Indonesia and in 2000, there were at least 7 provinces (North Sumatera, Lampung, Central Java, East Java, West Nusa Tenggara, East Nusa Tenggara and South Sulawesi) that produce corn as main food [1]. If the amount of corn produced with corn demand is insufficient, the country must import corn. In the 2000—2005 Indonesia recorded import corn between 226 thousand and 1.8 million tons to meet the demand for corn is higher than national corn production and not only that of corn imports continued during the period 2007-2011 in which the number of imported corn increased 3.1 million tons in 2011 [2].

Global climate change effect on agriculture as the growth of pest which cause damage to agricultural crops [3]. The progression of Plant Pest Organisms (OPT) is caused by changes in climate of uncertainty that affect the cultivation of plants in improving the quantity and quality of production [4]. Integrated Pest Management (PHT) should be done to control the progression of the pest and diseases. This activity is carried out by the farmers. Therefore the farmers must have the knowledge and skills to analyze the agro-ecosystem and take decisions on pest control that occurs on their la[18] [4].

Expert systems are one branch of artificial intelligence. Expert systems are computer programs that contain expert knowledge that is inserted into the system to solve the problems such as a way of thinking an expert in a particular scope [5, 6]. Expert systems have been built in various fields such as engineering, business, medicine, etc. The first expert system was built in 1965 by Edward Feingenbaum and Joshua Lederberg called DENDRAL to identify chemical compound [7]. After that, many expert systems are built further as MYCIN, XCON & XSEL, SOPHIE, FOLIO, DELTA, etc. One of the scope of the problem of expert systems is often built i.e., di[17]osis [6].

Many researchers who use expert systems in various fields, one of which is agriculture, such as an expert system for the protec[10] of the yield of wheat in Egypt called Expert System for Wheat Yields Protection in Egypt (ESWYP) that aims to diagnose the type of pest attacks that can attack wheat and suggestions for overcoming it [8].

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Besides, there is an expert system of pineapple disease that developed to facilitate pineapple farmers to acquiring knowledge and information about the disease of pineapple and this system have been applied in the Badung Regency Agriculture Department [9].

Additionally, in Pakistan there is also a web-based expert system for diagnosis of diseases and pests on wheat crop called Dr. Wheat where the system serves as a useful tool when farm labor cannot provide assistance when farmers need them [10].

There are several types of inference method of expert systems, one method often used is forward chaining. The forward chaining method is suitable for use in controlling and prognosis [11]. Forward chaining is a method to get a solution that starts with collecting information/ a set of known facts and check the premise that match with the facts in all rule to get goal/ conclusions [12].

For example, there is an expert system for disease management and variety selection of coconut using forward chaining [13] where forward chaining method work for chooses any possible rule that match with facts from the user to get the conclusion of a disease and solution.

This paper will discuss the implementation of the forward chaining method on expert system diagnosis of diseases and pests corn crop as a means for farmers to increase knowledge and skills of farmers on pests, diseases and how to control them. Forward chaining in this expert system will match the fact/ symptoms are selected by the user, then matched with rules in the database to get diagnostic results. Forward chaining method suitable for identifying diseases/ pests that attack corn crop based on facts/ symptoms that is selected by user and also the method is suitable for monitoring, prognosis, and solve problems.

FORWARD CHAINING METHOD

Forward chaining is one search method/ inference engine are used in expert systems by collecting information facts about the problem to infer/ get conclusions [6]. The Forward chaining method can be used for monitoring and diagnostics system because forward chaining can work quickly and solve the problems [14].

Search techniques of the forward chaining method start from the facts that matched with the premise in the IF-part of IF-THEN rules. If the premise is to fit the facts, so the rule is executed [15, 16]. There are three basic steps of the forward chaining method [15, 17]:

1. Match and find: the premises or condition of all rules are matched/ satisfied against content from databases to determine if the rule is applicable. All of rule are applicable will form a conflict set.
2. Select: select one or more rules from the conflict set for execution.
3. Act: activate conclusion from the selected rule in conflict set that get executed.

To choose the rule of conflict set in a second step, can use the several methods such as first come-first served, priority values, and metarules [17]. Priority value given to each rule and if the conflict set has more than one rule that match with the facts, then the rules are selected for execution is the rule that has the highest priority value [17].

IMPLEMENTATION FORWARD CHAINING METHOD ON DIAGNOSIS OF DISEASES AND PEST CORN CROP

Inference method to get diagnostic results in this system using a forward chaining method. Where the system will bring up a list of symptoms to be selected by the user. Symptoms are selected will be matched with the rule base in the system. All of the rules will be examined in the if-part. When there is if-part of a rule was matched with the selected symptoms by the user, so the rule is activated and then executed to be the diagnosis in the system diagnostics of diseases and pests of corn crop.

Figure 1 is a flowchart of implementation forward chaining [17] on the system diagnoses of diseases and pests corn crop.

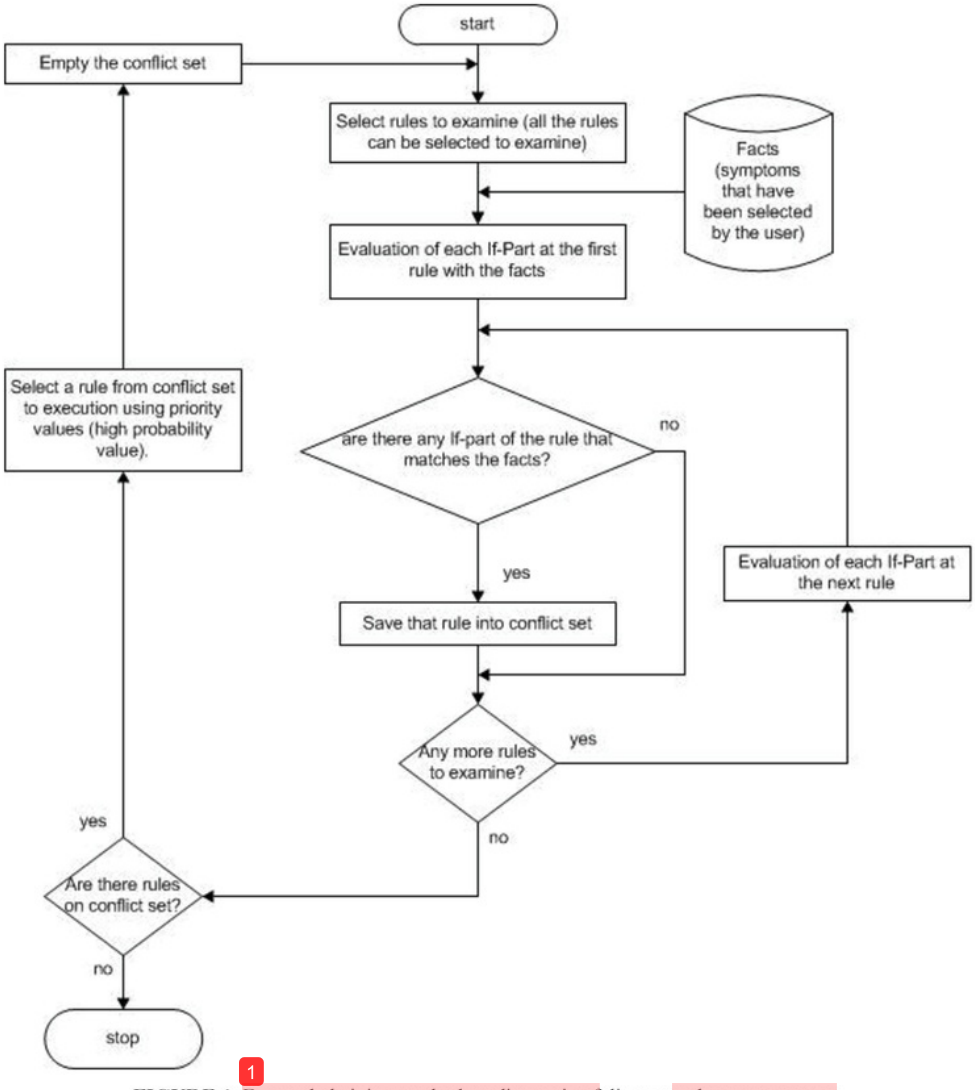

FIGURE 1. Forward chaining method on diagnosis of disease and pests corn crop.

This step forward chaining on diagnosis system of diseases and pests corn crop:

1. When user chooses symptoms, so that answers will be saved in working memory and the system will select rules to examination.

For example, there are 5 symptoms of the selected by the user to know the types of diseases/ pests that attack corn crop by symptoms. These symptoms are selected by the user:

a. Leaf perforated
b. The leaves are slightly yellow
c. Stems are holes throat
d. Rod easily broken
e. Not formed male flowers

The first stage of the workings forward chaining method that choose rules for examination and then the rule is evaluated by comparing the first part of the condition of the rule, if the condition of the first rule in accordance with the facts, then the rule is added to the conflict set. Add another rule that if there are rules in accordance with the facts about the conditions.

There are many rules in this system, i.e., downy mildew, rust, seed flies, leafhoppers, leaf blight, cob borer, stem borer, armyworm, black cutworm, leaf spot (Ras O), leaf spot (Ras T).

Then the system matches the If-part of the rule with all symptoms that have been selected by the user.

Rule 1 downy mildew:

> If the leaves are chlorotic and there are spores under leaf surface and leaves curled and twisted Then downy mildew

Symptoms are selected by the user:

> Leaf perforated, the leaves are slightly yellow, stems are holes throat, rod easily broken, not formed male flowers.

The system will match the first rule with the symptoms, it can be seen that there are no conditions/ premise that matches at the If-part of the first rule with symptoms that are selected by the user. Therefore, the system will check at the second rule.

Rule 2 Rust:

> If the surface of the top and bottom leaves are small patches and flecks round to oval and brown/ red patches of orange/ brownish black and there is a brownish yellow powder on patches and patches 0.2-2mm length and leaf dry up Then Rust.

When symptoms are selected by the user are matched by rule 2, it can be seen that no suitable conditions between the symptoms of the selected by the user with this rule. So, the system will search for the next rule to be checked.

If the next rule did not match, then go to the next rule again until the system found the rule in accordance with the symptoms selected by the user. Add that rule into the conflict set when if-part from that rule according with symptoms are selected by the user.

System found 3 rules which have suitable conditions with symptoms that have been selected by the user. Table 1 contains 3 rules (stem borer, seed flies, cob borer) that match the symptoms that have been selected by the user and that can be inserted into the conflict set.

TABLE 1. Rule that matches the symptoms of the selected user.

Fact/ Symptoms selected by the user	Disease/ pest	Symptoms of disease/pest	The same symptoms among the facts with the symptoms of the disease/pest	The number of the same symptoms among the facts with the symptoms of the disease/ pest
Leaf perforated		Leaf perforated	√	There are 5 symptoms stem borer in accordance with the facts of user
		The form of small holes in the leaves		
		The leaves are slightly yellow / yellow	√	
		There is a hole rod throat, sometimes the larvae were also found in the throat hole	√	
		There flour / dirt around the hole throat		
	Stem borer	Rod easily broken	√	
		The base of the cob are former throat		
The leaves are slightly yellow		Male flowers are former throat		
		The male flower (tassel) easily broken		
		There are heaps of male flower (tassel) damaged		
		The male flowers are not formed	√	
	Seed flies	Leaf perforated	√	There are 3 symptoms seed flies in accordance with the facts of user
		Larvae eat the leaves		
Stems are holes throat		The leaves are slightly yellow / yellow	√	
		Young leaves are still roll wither / dry		
		Parts of plants attacked by rot		
		The larvae bored into the base of the leaf		
		There is a hole rod throat, sometimes the larvae were also found in the throat hole	√	
Rod easily broken		Hole hoist up to the base of a rod-like tunnel		
		Occurs during the rainy season		
		Plant dwarf		
		Plants die		
	Cob borers	Perforated transverse leaf		There is 1 symptoms cob borers in accordance with the facts of user
		Corncob hair cut / reduced / dry		
The male flowers are not formed		There are scars throat at the tip of corn cobs		
		There larvae on the cob and eat the seeds corn		
		Larvae attack tassel		
		The male flowers are not formed	√	
		Yields declined		

2. The second step is to check the contents of conflict set. If there is no rule that is added to the conflict set, so the search is considered complete. If there are rules in conflict set, then the system will select the rule to be executed. Of the entire rule is in conflict set, the system will choose the one rule to be executed. In choosing the rule to be executed using several methods, and this system will choose the rule using priority values that have the highest probability of disease/ pest for executed.

To determine the probability of the corn crop disease/ pest based on symptoms, then uses the equation of probability. The percentage value of disease/ pest is calculated base on the number of symptoms that fulfilled/ selected by the user divided (÷) by the number of symptoms of the disease/pest. But sometimes some diseases have

similar symptoms. Therefore to get a percentage of the same symptoms then applied equation of probability to find the percentage of each of these symptoms in any disease as following:

$$p(A) = \frac{n(A)}{N} x100\% \quad (1)$$

Where P(A) is the probability of the occurrence of A disease, n(A) is one of the symptoms of A disease, N is the sum of all the symptoms that can cause A disease.

For example, to find the probability of each symptom on the stem borer is to apply the equation of probability as follows:

$$p(A) = \frac{n(A)}{N} x100\%$$
$$p(A) = \frac{1}{11} x100\%$$
$$p(A) = 9\%$$

Where P(A) is the probability symptoms of leaf perforated from stem borer, n(A) is a constant for perforated leaf symptom and N is the total number of symptoms in stem borer. After that, insert 1 as a constant value at n(A) and 11 in N, then obtained the probability for leaf perforated symptom by 9%, this percentage is also the same value for all symptoms in stem borer.

If two or more types of diseases have similar symptoms, then totalizing percentage of symptoms in each disease then divided by the amount of disease that have similar symptoms and then the value of probability of symptoms owned more than one diseases has changed. And to get the value of the probability of corn crop that attack disease/ pests based on symptoms then entire totalizing probability value for each symptom that has been selected by the user.

In this expert system, there are some diseases/pests that have same symptoms as the other diseases/ pests such as stem borer and seed flies that have same symptom that leaf perforated. So, to get the average probability of the leaf perforated by summing the percentage probability that the symptom of leaf perforated contained on the stem borer and seed flies and then divided by 2.

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \quad (2)$$
$$\bar{x} = \frac{x_1 + x_2}{n} = \frac{9\% + 9\%}{2} = \frac{18\%}{2} = 9\%$$

In the equation 2, $\bar{x}$ is the average probability of leaf perforated symptom, x_1 is the probability of leaf perforated symptom on stem borer and x_2 is the probability of leaf perforated symptom on seed flies. The value of n is 2 because the number of pests that have same symptoms are symptom of leaf perforated just stem borer and seed flies.

Using the equation of probability in determining the probability corn crop attacked by disease/ pest based on symptom selected by the user, the system getting the percentage of each rule contained in the conflict set is 47% corn crop attacked by stem borer, 27% attacked by seed flies and 11% attacked by cob borer.

3. The next step is activate conclusion from selected rule in conflict set. The system chooses rule of stem borer to be executed because the system choose the rule that has the highest probability value of all the rules in the conflict set. So, the last step is activating Then-part from stem borer rule as the conclusion/ diagnose result.

RESULT AND ANALYSIS

This system using the case testing method as the validation system that uses a set of data to be processed using the system then the results will be compared with an expert answer. The data set (data case) is derived from a collection of symptoms of various diseases and pests that attacked the corn crop farmers where all the symptoms of

each data will be diagnosed by the system and that result will be compared with the diagnosis results of a human expert. Data case that used in this study came from the interview to some farmers.

An expert do diagnostic manually by seeing, observing the symptoms that attacks the corn plants. If a human expert has not been able to identify the type of disease/ pest that attack the corn crop, so the human expert will take part of the affected plants to be brought to the laboratory. But if the user uses the system, the user simply selects the symptoms that attack corn crop and the system will diagnose diseases / pests that attack corn crop based on the symptoms that have been selected by the user.

To validate the system, this system uses 36 cases (data set/ data case) of the disease / pests that have attacked on several farmers as samples of known diagnosis results manually (by human expert) and will be compared with the results of system diagnosis with symptoms similar input on the system. Table 2 presents a comparison of the results of the diagnosis of pest of corn crop, while table 3 presents a comparison of corn crop disease diagnosis results.

TABLE 2. Comparison table of pests diagnosis results between the result of manual diagnosis and diagnosis expert system

Data case	The result of the diagnostic manual by human expert	The result of the diagnostic by exert system	Matches diagnosis
Data case 1	Stem borer	Stem borer	1
Data case 2	Stem borer	Stem borer	1
Data case 3	Seed flies	Seed flies	1
Data case 4	Stem borer	Stem borer	1
Data case 5	Cob borer	Cob borer	1
Data case 6	Armyworm	Armyworm	1
Data case 7	Armyworm	**Undefined**	**0**
Data case 8	Stem borer	Stem borer	1
Data case 9	Stem borer	Stem borer	1
Data case 10	Stem borer	Stem borer	1
Data case 11	Stem borer	**Undefined**	**0**
Data case 12	Stem borer	Stem borer	1
Data case 13	Stem borer	Stem borer	1
Data case 14	Leafhoppers	Leafhoppers	1
Data case 15	Black cutworm	Black cutworm	1
Data case 16	Leafhoppers	Leafhoppers	1
Data case 17	Cob borer	Cob borer	1
Data case 18	Armyworm	Armyworm	1
Data case 19	Stem borer	**Undefined**	**0**
Data case 20	Cob borer	Cob borer	1
Data case 21	Seed flies	Seed flies	1
Data case 22	Leafhoppers	Leafhoppers	1

TABLE 3. Comparison table of disease diagnosis results between the result of manual diagnosis and diagnosis expert system

Data case	The result of the diagnostic manual by human expert	The result of the diagnostic by exert system	Matches diagnosis
Data case 1	Downy mildew	Downy mildew	1
Data case 2	Rust	Rust	1
Data case 3	Downy mildew	Downy mildew	1
Data case 4	Downy mildew	Downy mildew	1
Data case 5	Turcicum leaf blight	Turcicum leaf blight	1
Data case 6	Turcicum leaf blight	Turcicum leaf blight	1
Data case 7	Turcicum leaf blight	Turcicum leaf blight	1
Data case 8	Downy mildew	Downy mildew	1
Data case 9	Turcicum leaf blight	Turcicum leaf blight	1
Data case 10	Downy mildew	Downy mildew	1
Data case 11	Downy mildew	Downy mildew	1
Data case 12	Downy mildew	**Undefined**	**0**
Data case 13	Turcicum leaf blight	Turcicum leaf blight	1
Data case 14	Rust	Rust	1

Description:

- 0 if the diagnosis manually with expert system does not give the same result
- 1 if the diagnosis manually with expert system provides the same result

Based on the results of the comparison, it can be concluded that 32 data showed the same diagnostic results between the system with diagnostic manual by an expert from 36 data cases. So, the percentage accuracy of an expert system in diagnostic diseases and pests corn crop is 88.88%.

Differences between diagnosis expert system with agricultural experts due to the complexity of the rule. Rule contained in the knowledge base can be repaired and equipped to get results more accurate diagnosis.

CONCLUSION

The forward chaining method implemented in this system works by tracking the symptoms that match between the symptoms of the rule and the symptoms are selected by the user. If forward chaining finds a rule with premises/ conditions/ symptoms that contained in the rule is worth the same as the symptoms of the selected user, so Then-part of the rule will be executed for the conclusion/ diagnosis. This system uses a validation through case testing by way of comparing the results of diagnostic systems and the results of diagnostic by human experts. There are 36 data from some of the symptoms of diseases and pests that are used as data case, where 32 data shows the same diagnosis results between this system and diagnosis results by a human expert. 4 data cases yield a different diagnosis. The difference in the results of the diagnoses is caused by the rule base in this system. Forward chaining methods do not find the rule corresponding to the symptoms that are chosen by the user. The complexity of the rule in this knowledge base is very influential in generating conclusions diagnosis. Increasing complex rule which was built, then the system will yield an accurate diagnosis. So, it can be concluded that this diagnostic system can be used to diagnose diseases and pests based on symptoms chosen by the user with an accurate percentage 88% is derived from the 32 data cases yield the same diagnosis between the results of diagnostic system and the results of the diagnosis by human experts. So, this system diagnosis can be used to help farmers for increase knowledge and skills about diseases, pests, and how to control them.

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