Expert system for corn plant disease diagnosis with the breadth-first search method

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Abstract. Corn is one of the most important carbohydrate-producing food plants in the world, besides wheat and rice. But farmers often experience crop failures caused by disease attacks on corn plants. Some diseases that interfere with the productivity of maize plants are downy mildew, leaf spot disease, leaf rust disease, dwarf virus disease, midrib rot, stem rot and swollen burns. If the disease in corn plants is not known quickly, then the handling will be too late so that the plant will not develop, stop producing even the corn plants can die. This can lead to reduced yields and also cause crop failure. To overcome this problem, an expert system application for diagnosing maize diseases was made by adopting expert knowledge into the system using the breadth first search method that provides information about plant diseases and can diagnose symptoms of plant diseases, especially corn plants, while providing a solution to overcome them, which can later be used to reduce or reduce the risk of damage plant.

1. Introduction
Corn is one of the foods which rich in fiber, both soluble and insoluble fiber. Soluble fiber could block cholesterol absorption. Corn is mealy vegetables which capable give energy on the body and its included in the types carbohydrates complex. So that the consumption of types of carbohydrates complex can provide a more prolonged feeling of satiety and make stable energy. The Ministry of Agriculture's Plantation Office, Mr. Bambang argues that plantation areas have extensive potential to be used as intercropping areas by developing food crops between plantation crops and preparing 1 million hectares for corn development [1]. But there are not a few problems faced by farmers when cultivating corn. There are three main problems faced by farmers, namely pests, diseases, and weeds. If corn attacked by pests, it can lose 70% of the yield that should have been able to be obtained. If corn attacked by disease, it would lose 90%. Then, if the weeds light, it would decrease by 45% [2].

One alternative to reduce crop failure and increase farmers' knowledge is through mentoring by corn experts or agricultural extension officers. But there are limitations to the number of corn experts in terms of consulting directly about corn disease. For that reason, this research made an expert system application that provides information about plant diseases and the application also can diagnose the symptoms of plant diseases, especially corn plants. In addition, that application also may able to provide a solution to overcome the symptoms of plant diseases, which can later be used to reduce or reduce the risk of damage to plants. Computer-based expert systems can be used to help solve problems in terms of helping each farmer in determining treatment options. [2] This research used Breadth-First-Search method, Breadth-First Search method used all node at n level will be visited.
first and then visiting nodes at level n+1. Search will start from the root node and then to level k-1 from left to right, then moves to the next level as well as from the left to the right until the solution is reached [4].

2. Methods
This study began with an analysis of symptoms of pests and diseases in corn plants. Then make knowledge-based rules on the symptoms found.

2.1 Expert System
Expert system is one part of artificial intelligence which has experienced rapid development. In general, expert systems are systems that try to adopt human knowledge to computers, so that computers can solve problems like experts. Expert system is a computer program designed to model the ability to solve problems carried out by an expert [5].

2.2 Breadth-First Search (BFS)
Breadth First Search (BFS) method is a search method that is done by visiting each node systematically at each level to the destination (goal state) found. In the Breadth First Search method, all nodes at level n will be visited first before visiting node at level n + 1. The search starts from the root node to level 1 from left to right then moves to the next level as well as from left to right so that a solution is found. [4]. In other words, at first, visit all nodes that are level to find the goal of the state. Breadth First Search also can be interpreted as a node search algorithm in a graph (tree) by travels which starts from the root node and checks all neighboring nodes.

After that, from each neighboring node, the algorithm will continue to check to all neighboring nodes that have not been checked, so on until they find destination node Breadth First Search. The rule interpreter starts from the existing facts, namely the hypothesis, then the rule of the THEN section starts to be tested to support the initial hypothesis. If found, a suitable IF rule is used to generate a hypothesis between the new ones. Then the chain process continues to be repeated, gathering supporting evidence, so the hypothesis is proven to be true.

2.3 Rule
Rule provide formal way to present recommendation, directives, or strategy [6]. Rule production can be:

\[
\begin{align*}
&\text{IF [Premis] THEN [Conclusion]} \\
&\text{IF [input] THEN [output]} \\
&\text{IF [Condition] THEN [action]} \\
&\text{IF [Anteseden] THEN [Consequen]} \\
&\text{IF [Data] THEN [Result]} \\
&\text{IF [action] THEN [Purpose]}
\end{align*}
\]
Figure 1. Flowchart System

Premise referring to on the fact that must be right before conclusion particular could be obtained then give confidence weight by experts.

3. Results and Discussions
The data output of this system are the types of diseases, symptoms, and control solutions. For data on diseases and symptom relations shown in Table 1.

Table 1. Relationship between disease and symptoms [7]

| Disease code | Disease Name       | Symptoms                                                                 |
|--------------|--------------------|--------------------------------------------------------------------------|
| PT01         | Bulai              | • Yellow stripes on leaf                                                 |
|              |                    | • Lines covered in white flour                                           |
|              |                    | • Whitish yellow on leaf                                                 |
|              |                    | • The leave is stiff                                                     |
|              |                    | • Small plants/stem shorten                                              |
|              |                    | • Cob formation is inhibited                                             |
|              |                    | • Small Cob                                                              |
| PT02         | Bercak Daun        | • Have spots round to oval                                               |
|              |                    | • Spots colored yellow on leaf                                           |
|              |                    | • Plant Colored chocolate young to old                                   |
|              |                    | • Wet plants                                                             |
|              |                    | • In the middle have brown spots                                         |
| PT03         | Karat Daun         | • Spots/ small red rust stains                                           |
|              |                    | • There is yellowish brown/yellow flour                                   |
| PT04         | Virus Kerdil       | • Yellow stripes on leaf                                                 |
|              |                    | • Small plants/stem shorten                                              |
|              |                    | • small Cob                                                              |
|              |                    | • Disjointed lines along the leaf surface                                |
| PT05         | Busuk Pelapah      | • Spots on the midrib                                                    |
|              |                    | • Salmon color spots                                                     |
The determination of the type of disease in corn plants with existing symptoms, as shown in Table 2:

**Table 2. Corn crop rule**

| Symptoms code | PT01 | PT02 | PT03 | PT04 | PT05 | PT06 | PT07 |
|---------------|------|------|------|------|------|------|------|
| G1            | √    |      |      |      |      |      |      |
| G2            | √    |      |      |      |      |      |      |
| G3            | √    |      |      |      |      |      |      |
| G4            | √    |      |      |      |      |      |      |
| G5            | √    |      |      |      |      |      |      |
| G6            | √    |      |      |      |      |      |      |
| G7            |      |      |      |      |      |      |      |
| G8            |      |      |      |      |      |      | √    |
| G9            |      |      |      |      |      |      | √    |
| G10           |      |      |      |      |      |      | √    |
| G11           |      |      |      |      |      |      | √    |
| G12           |      |      |      |      |      |      | √    |
| G13           |      |      |      |      |      |      | √    |
| G14           |      |      |      |      |      |      | √    |
| G15           |      |      |      |      |      |      | √    |
| G16           |      |      |      |      |      |      | √    |
| G17           |      |      |      |      |      |      | √    |
| G18           |      |      |      |      |      |      | √    |
| G19           |      |      |      |      |      |      | √    |
| G20           |      |      |      |      |      |      | √    |
| G21           |      |      |      |      |      |      | √    |
| G22           |      |      |      |      |      |      | √    |
| G23           |      |      |      |      |      |      | √    |
| G24           |      |      |      |      |      |      | √    |
| G25           |      |      |      |      |      |      | √    |
Decision making rules as follows:

| Rules for Symptoms of Disease |
|--------------------------------|
| if $G1 \land G2 \land G3 \land G4 \land G5 \land G6 \land G7 \rightarrow PT01$ |
| if $G8 \land G9 \land G10 \land G11 \land G22 \rightarrow PT02$ |
| if $G12 \land G13 \rightarrow PT03$ |
| if $G1 \land G5 \land G7 \land G14 \rightarrow PT04$ |
| if $G15 \land G16 \land G17 \land G21 \land \rightarrow PT05$ |
| if $G18 \land G19 \land G20 \land G21 \rightarrow PT06$ |
| if $G23 \land G24 \land G25 \rightarrow PT07$ |

One example of decision making is if the system asks users the yellow stripes on the leaf (G1), and the answer is Yes. Next, the system asks the question of Lines covered in white flour (G2), and the answer is Yes. Then, the system asks Whitish yellow on the leaf (G3), and the user answers Yes. Next, the system asks the question Stiff Leaves (G4) and and the answers is Yes. Later on, the system to ask Small plants/stem shorten (G5) and the answers is Yes. Furthermore, the system ask is Cob formation is inhibited (G6) and and the answers is Yes. As well as the system ask Small-scale Cob (G7) and and the answers is Yes. At last, the system will conclude that the plant suffers from bulai (PT01).

The reasoning flow or decision tree in the breadth First Search can be seen in Figure 2.

**Figure 2.** Decision tree for the diagnosis of corn disease expert system

4. **Conclusion**

Based on data analysis, it can be concluded that the create application can help the farmer to cope with diseases that are attacking their corn plants, and also this application is responsive when interacting with users. In addition, the result of the measurement of information system performance using the accuracy formula direct the researcher to conclude that the accuracy of the information system reaches 90% and or it is feasible to use.
5. Reference

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