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The Innovation Breakthrough in Digital and Disruptive Era

Expert System to Diagnose Diseases in Corn Plant Using Mobile-Based Forward Chaining And Certainty Factor Methods

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Abstract. Technological developments are so rapid and have an impact on all fields. For example in agriculture. The expert system is part of artificial intelligence (AI) which can be used in diagnosing diseases in corn plants. Corn is a food crop that can be found in Indonesia. Erratic season changes can trigger diseases in corn plants so that it becomes a problem for farmers. The problem that is often encountered by farmers is the difficulty in diagnosing the disease from the corn plant. Therefore an expert system will be built that aims to diagnose diseases in corn plants using the forward chaining method and mobile-based certainty factor. By using the forward chaining method and the certainty factor, the accuracy value obtained by the system for 25 times the testing process is 84% and makes this system good enough to use. The system is applied to a mobile-based application so that usage can be more efficient.

1 Introduction

Technological developments are growing rapidly and have an impact on all fields. The technological capabilities that exist in the software must be balanced by sophistication. Several sectors in life have been diverted using technology. For example, in the agricultural sector in corn cultivation, it is necessary to have the role of technology in the cultivation process [1].

Corn is a food crop that is used as a staple food in Indonesia, especially on the island of Madura. In addition, corn is also the main ingredient such as flavoring and flour. Over time it causes an increase in the need for staple foods such as corn [2]. Erratic season changes can trigger diseases in corn plants so that it becomes a problem for farmers [3]. Errors in dealing with diseases that attack corn plants are one of the problems that are often done by most farmers [4], [5]. Farmers need to increase their knowledge of how to deal with diseases in corn plants. An expert system is one way out that will diagnose diseases in corn plants to help farmers get further information about diseases that are attacking corn plants [6-8].

The expert system is part of Artificial Intelligence (AI) which was discovered by the AI community in the mid-1960s. The expert system was created to assist experts in transferring their expertise to a computer and can be called up by the user when needed to be able to provide information in the form of explanations to the user. An expert system is also software that has the knowledge of an expert in dealing with problems [9].

Forward Chaining is a method that can be used to develop expert systems. The approach to decision making known as the "Forward Chain" starts from considering the facts before making a final conclusion. This strategy uses data and is implemented by

adjusting the input data and trying to provide conclusions [10].

Certainty factor is a method or an algorithm that is used when facing a problem with uncertain answers in the form of a matrix. This method states a conclusion in an uncertain event based on facts or expert judgment [11], [12].

Therefore, with the problems that are often experienced by farmers, especially corn farmers in diagnosing a disease in corn plants, an Android-based expert system will be designed with forward chaining and certainty factor as the method to be used in the application. This expert system application is expected to assist farmers in diagnosing diseases in corn plants so that farmers can get solutions in dealing with these diseases.

2 Research methods

2.1 Forward Chaining

Forward Chaining is a fact-matching method using IF-THEN (action conditions). For facts that match the IF section, the rule is executed. When the rules are executed, new facts are added to the database (TIE section). Each time it is matched, it starts with the parent rule. Each rule can only be executed once. The reconciliation process stops when there are no more rules to follow. The following is the flow of forward chaining :

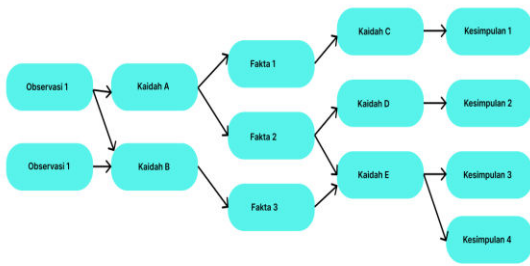


Fig. 1. Forward Chaining Method Algorithm Architecture
 The steps for creating an expert system using the forward chaining method are as follows:

1. Problem definition begins with the selection of problem areas and information gathering
2. Determine the input data to start reasoning as required by the feedforward system.
3. Define a data management structure to control rule activation.
4. Writing the initialization code to the data area
5. Testing the system to find out how long the system is running
6. User interface design with database
7. System development
8. System evaluation

2.2 Certainty Factor

Calculation steps in the certainty factor method to build an expert system for diagnosing pests and diseases in corn plants are as follows :

1. Determination of pest and disease data.
2. Determination of symptom data.
3. Determination of combined data, the combined data here is a combination of symptom data and pest and disease data.
4. Determination of the MB MD value is followed by determining the CF value.
5. Selection of symptom data by the user.
6. Calculation of CF values from user symptoms.
7. Results of pest or disease diagnosis.

The result of the expert system diagnosis is the percentage of disease. The percentage of disease used for diagnosis is the largest percentage. The percentage of disease is obtained from the calculation of the certainty factor value based on the symptoms selected by the user. The calculation of the certainty factor value is as follows :

Calculating CF Value :

$$CF[H,E] = MB[H,E] - MD[H,E] \tag{1}$$

Information :

- CF(H,E) : certainty factor of the hypothesis H which is influenced by evidence (evidence) E. The magnitude of CF ranges from -1 to 1. A value of -1 indicates absolute distrust, while a value of 1 indicates absolute trust.
- MB(H,E) : measure of increased belief in hypothesis H which is affected by symptom E.

- MD(H,E) : measure of increased disbelief towards hypothesis H which is affected by symptom E.
- Calculating the CFcombine Value :

$$CFcombineCF[H,E]1,2 = CF[H,E]1 + CF[H,E]2 * [1 - CF[H,E]1] \tag{2}$$

3 System And Database Design

3.1 System Flowcharts

The stages in the system begin with the display of the main page in the form of a menu list, then selecting the consultation menu to determine the symptoms of the disease so that the results of the analysis and treatment are obtained.

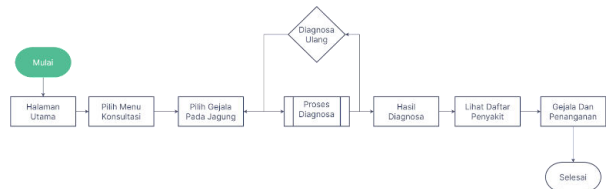


Fig. 2. Flowchart Design

3.2 Context Diagram

In the design of a system, a flow context diagram is needed to see the flow of the system to be made. In this study there are 2 entities, namely users and experts. Users are people who use applications while experts are entities that process requests from users according to orders and according to what is discussed in this study.

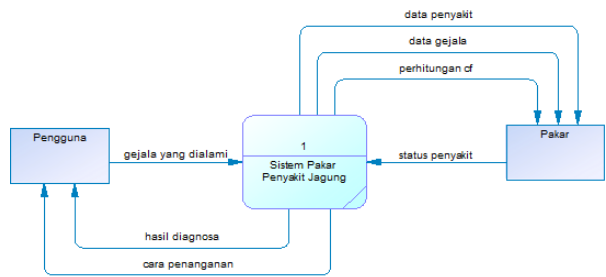


Fig. 3. Context Diagram Design

3.3 DFD Level 0

Data Flow diagram level 0 is a detailed explanation of each process in the previous flowchart design and context diagram. In this section the data flow is described in detail. At DFD level 0 this is a derivative of the previous context diagram which has 2 entities and it's just that DFD level 0 explains more detailed system and data process flows.

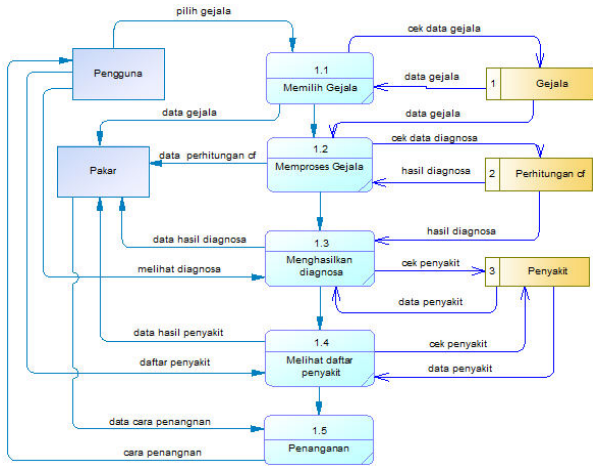


Fig. 4. Design Data Flow Diagrams Level 0

3.4 ER Diagram

In the database design for the development of the corn disease detection application, there are three tables, namely symptoms, diseases and symptoms_has_disease. The symptom table has 2 attributes, namely symptom_code as with the data type varchar used as the primary key and symptom_name attribute. The disease table has 4 attributes, namely code_disease, name_disease, description and treatment, the disease code is used as the primary key.

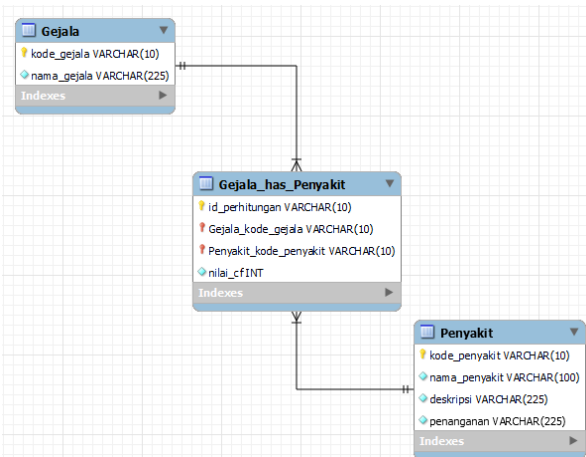


Fig. 5. Entity Relationship Diagram Design

3.5 Desain UI

The following is the design of this expert system application, the application will be deployed into a mobile-based application to make it easier for users. Menu About



Fig. 6. About Menu Interface Design

Disease List Menu

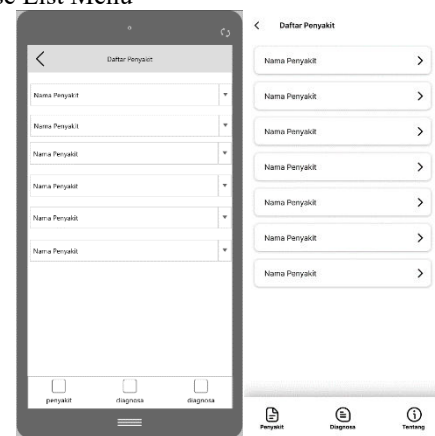


Fig. 7. Disease List Interface Design

Diagnostics Menu

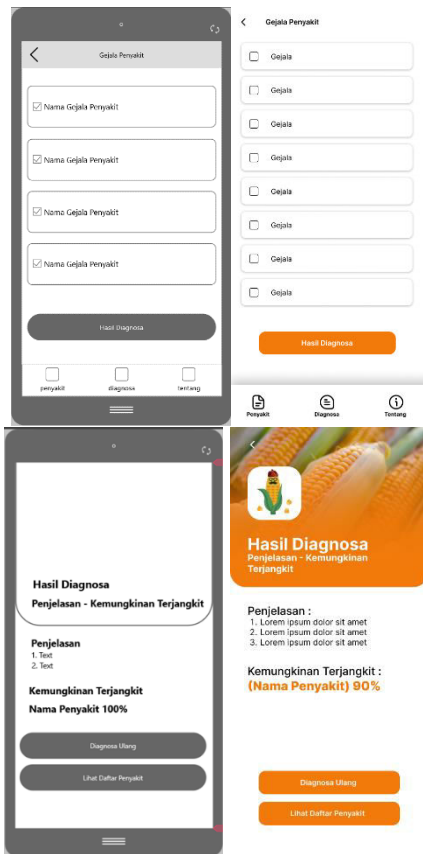


Fig. 8. Menu Interface Design and Diagnostic results

Handling Menu



Fig. 9. Handling Menu Interface Design

codes from symptoms that will be used in identifying a disease and displaying detailed symptoms by displaying the characteristics of the disease.

TABLE I. Corn Disease Symptom Data

Table 1. Setting Word's margins.

Code	Symptom Data	Code	Symptom Data
G1	Yellow stripes on leaves	G14	Dotted lines all over the leaf surface
G2	White flour covered line	G15	Spots are gray / whitish
G3	The leaves are whitish yellow	G16	Spots on the fronds
G4	Stiff leaves	G17	Salmon color blotches
G5	Dwarf Plants / Short stems	G18	Widespread patches of gray or white color
G6	Cob formation is inhibited	G19	Plants break suddenly
G7	Small cobs	G20	Brown color on the lower stem nodes
G8	Round to oval patches	G21	Stems wet, soft, and Ringed
G9	Yellow spots on leaves	G22	Smells bad
G10	Plants Light brown to dark	G23	In the middle of the brown spots
G11	Wet plant	G24	The seeds contain white to gray brown mushrooms
G12	Small rusty red spots/stains	G25	Rot is pink or reddish to brown

4.2 Disease Data

With disease data, this diagnostic system can match symptoms reported by farmers with a list of associated diseases. The purpose of this is to help make a targeted diagnosis and provide a solution. Use a two-column format, and set the spacing between the columns at 8 mm. Do not add any page numbers.

Table 2. Maize Disease Data

Disease Code	Disease Name
P01	Bulai
P02	Leaf Spot
P03	Leaf Rust

4 RESULTS AND DISCUSSION

Based on data regarding corn disease obtained from an actual situation to support the accuracy of the diagnosis results. Data obtained from experts and literature studies. The following is data in the form of symptom data, disease data and solutions :

4.1 Symptom Data

The following is symptom data presented in tabular form. Symptom data is obtained from experts with

Disease Code	Disease Name
P04	Dwarf Virus
P05	Leaf Rot
P06	Stem Rot
P07	Cob Rot

4.3 Solution Data

Solution data is information data about actions that can be used to overcome registered corn disease with recommended treatment regimen control measures. The aim is to provide practical guidance to farmers on how to deal with diseases in corn plants.

Table 2. Solution Data

Disease Code	Solution Data
S01	Planting downy mildew resistant varieties such as Bima 1, Bima 3, Bima 9, Bima 14, Bima 15, Lagaligo, or Gumarang varieties.
	Do a corn crop free time period of at least two weeks to one month.
	Simultaneous planting of corn.
	Destruction of all parts of the plant down to the roots (Eradication of plants) in plants attacked by downy mildew.
	Use of metalaxyl fungicide during seed treatment at a dose of 2 grams (0.7 g of active ingredient)/kg of seed.
S02	Plant varieties resistant to leaf spot attack, such as Bima-1, Srikandi Kuning-1, Sukmaraga or Palakka.
	Destroy all parts of the plant down to the roots (Eradication of plants) on plants infected with leaf spots.
	The use of fungicides uses the active ingredients mancozeb or carbendazim. Dosage / concentration according to packaging instructions.
S03	Plant leaf rust-resistant varieties, such as Lamuru, Sukmaraga, Palakka, Bima-1 or Semar-10.
	Destruction of all parts of the plant down to the roots (Eradication of plants) on plants infected with leaf rust or weeds.
	Spraying fungicide using the active ingredient benomyl. Dosage / concentration according to packaging instructions.
S04	Remove virus-infected corn plants as early as possible so that they do not become a source of infection for surrounding plants or next season's plantings.
	Do crop rotation, do not plant corn crops continuously on the same land.

Disease Code	Solution Data
S04	Spraying pesticides when the vector population is high enough in the field. Dosage / concentration does not exceed the recommendations on the packaging.
	Do not plant corn seeds from virus-infected plants.
S05	Using varieties/strains resistant to moderately resistant to sheath blight such as: Semar-2, Rama, GM 27 lines.
	Try not to plant corn too tightly so that the humidity is not too high.
	The land has good drainage.
	Crop rotation, do not plant corn continuously on the same land.
S05	Spraying fungicide using the active ingredient mancozeb or carbendazim. Dosage / concentration according to the instructions on the package
	Planting varieties resistant to stem rot such as BISI-1, BISI-4, BISI-5, Surya, Exp.9572, Exp. 9702, Exp. 9703, CPI-2, FPC 9923, Pioneer-8, Pioneer-10, Pioneer-12, Pioneer-13, Pioneer-14, Semar-9, Palakka, or J1-C3.
	Do crop rotation.
	Perform balanced fertilization, avoid giving high N and low K and good drainage
	Biological control of stem rot disease (Fusarium) can be carried out with the antagonistic fungus Trichoderma sp.
S07	Carry out balanced fertilization.
	Don't let the cob dry out in the fields for too long, if the rainy season arrives the part of the stem under the cob is broken so that the cob end doesn't face upwards.
	Carry out crop rotation which does not include grains because this portagen has many host plants

4.4 Knowledge Base of Symptoms and Diseases of Corn Plants

The knowledge base of symptoms and diseases of maize plants is the result of the suitability of the samples of symptoms and diseases that have been obtained. After the analysis stage of disease data and symptom data, the explanation is as follows in tabular form :

Table 4. Calculation of the certainty factor results

No	G/P	P01	P02	P03	P04	P05	P06	P07
1	G1	✓			✓			
2	G2	✓						
3	G3	✓						
4	G4	✓						
5	G5	✓			✓			
6	G6	✓						
7	G7	✓			✓			
8	G8		✓					
9	G9		✓					
10	G10		✓					
11	G11		✓					
12	G12			✓				
13	G13			✓				
14	G14				✓			
15	G15							
16	G16						✓	
17	G17						✓	
18	G18						✓	
19	G19							
20	G20							
21	G21					✓		
22	G22					✓	✓	
23	G23		✓					
24	G24							✓
25	G25							✓
26	G26							✓

4.5 Accuracy Testing Results

25 data samples were used to test the system using the forward chaining method and certainty factor, the data used as samples were images of corn plant diseases on research objects.

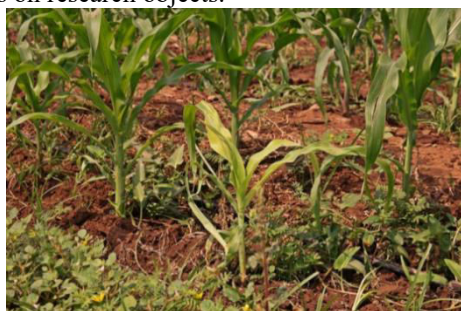


Fig. 10. first case study

Farmers experience complaints on their corn plants with the following categories :

1. G1 There are yellow lines on the leaves with an assumption of 0.05

2. G7 Formation of small cobs with an assumption of 0.05 confidence
3. G22 Smells bad with 0.05 sure assumption

So the solution is as follows :

- Forward Chaining

The first time a diagnosis was made of the criteria for corn disease on the input data, the following are the results of the diagnosis :

Table 5. Completion of Forward Chaining Case 1

No	Queue	G	R	P
1	R1, R2, R3, R4, R5, R6, R7	G1, G7	R1, R4	P1, P4
2	R2, R3, R4, R5, R6, R7	G22	R5	P5
3	R2, R3, R4, R6, R7	-	-	-

The symptoms that were sentenced were :

1. [G1] Yellow-yellow streaks on the leaves
2. [G7] Small cobs

3.[G22] It stinks

With these symptoms, there are 2 verdicts against the disease namely :

P1 – Downy mildew with symptoms G1 and G7

P4 – Dwarf disease with symptoms G1 and G7

- Certainty Factor

To calculate the certainty value to determine what disease is experienced in the corn plant, the certainty factor is calculated.

Table 6. Completion of Forward Chaining Case 1

P1	P4
$F(H, e)$ $= CF(E, e) \times CF(H, E)$ $X1[G1] = 0.8 \times 0.5$ $= 0.4$ $X2[G7] = 0.8 \times 0.5$ $= 0.4$ $CF(A)$ $= CF(X1) + CF(X2)$ $\times [1 - CF(X1)]$ $0.4 + 0.4 \times (1 - 0.4)$ $= 0.64$	$CF(H, e) = CF(E, e)$ $\times CF(H, E)$ $X1[G1] = 0.93 \times 0.5$ $= 0.465$ $X2[G7] = 0.90 \times 0.5 = 0.45$ $CF(A) = CF(X1) + CF(X2)$ $\times [1 - CF(X1)]$ $0.465 + 0.45 \times (1 - 0.465)$ $= 0.70575$



Fig 12. The results of case study 1 in the application

The test was carried out again 24 times with the same calculation as test 1, the results obtained are as follows :

4.6 Overall Testing Recap

Table 7. Results of all tests

No	Case	Results
1	Kasus 1	Suitable
2	Kasus 2	Suitable
3	Kasus 3	Suitable
4	Kasus 4	Not suitable
5	Kasus 5	Suitable
6	Kasus 6	Suitable
7	Kasus 7	Suitable
8	Kasus 8	Suitable
9	Kasus 9	Suitable
10	Kasus 10	Suitable
11	Kasus 11	Suitable
12	Kasus 12	Suitable
13	Kasus 13	Not suitable
14	Kasus 14	Not suitable
15	Kasus 15	Suitable
16	Kasus 16	Not suitable
17	Kasus 17	Suitable
18	Kasus 18	Suitable
19	Kasus 19	Suitable
20	Kasus 20	Suitable
21	Kasus 21	Suitable
22	Kasus 22	Suitable
23	Kasus 23	Suitable

No	Case	Results
24	Kasus 24	Suitable
25	Kasus 25	Suitable

5 CONCLUSION

The forward chaining and certainty factor methods are good enough to be combined as methods in this expert system application. The accuracy obtained for 25 times of testing is 84%, indicating that this method is good enough. The application can run well on mobile devices so that it makes it easier for farmers (users).

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