

Expert System for Disease Identification in Palawija Plants with the Dempster Shafer Method

Wanda Ilham¹, Sapta Eka Putra², Dasril Aldo³, Yohani Setiya Rafika Nur⁴, Annisaa Utami⁵

¹Department of Informatic Engineering, Catur Insan Cendekia University Cirebon, Cirebon 45133, Indonesia

²Department of Retail Management, Tamansiswa University of Padang, Padang 25171, Indonesia

^{3,4,5}Department of Informatics, Institut Teknologi Telkom Purwokerto, Purwokerto 53147, Indonesia

ARTICLE INFO

Article historys:

Received : 05/09/2023

Revised : 29/09/2023

Accepted : 12/10/2023

Keywords:

Dempster Shafer; Identification; Expert System Crop Diseases; Corn Crops

ABSTRACT

Crops, including corn, are important agricultural commodities and contribute greatly to people's food needs. Diseases in crops are often the main factor that reduces crop production and quality. Maize plants are particularly susceptible to various pests and diseases, such as Leaf Blight, Leaf Spot, Rust, Stem Blight, Anthracnose, Root Rot, Cob Rot, Smut, Mosaic Virus, and Nematodes. Unfortunately, farmers often use pesticides or inappropriate control methods, resulting in suboptimal care and the emergence of new pests or diseases. This study aims to assist farmers in detecting early symptoms of pests and diseases in corn plants, so that control can be more precise and effective. In this study, 10 disease attack data were processed using the Dempster-Shafer method. This method processes data based on symptoms seen in corn plants, allowing detection of types of pests and diseases and recommendations for handling them with an accuracy rate of about 80%. Therefore, the Dempster Shafer method is relevant for use in the identification of diseases in corn plants.

Copyright © 2023. Published by Bangka Belitung University
All rights reserved

Corresponding Author:

Dasril Aldo

Department of Informatic Engineering, Catur Insan Cendekia University Cirebon,
Jl. Kesambi No.202, Cirebon 45133, Indonesia

Email: dasril@ittelkom-pwt.ac.id

1. INTRODUCTION

Crops are one of the important commodities in agriculture that contribute greatly to the food needs of the community. However, disease attacks on crops are one of the main factors that cause a decrease in production and yield quality. Therefore, the development of an expert system for identifying diseases in crops is very important to help farmers and agricultural experts in overcoming this problem.

In this modern era, the development of information technology has made significant contributions in various fields including agriculture. One technology that has been widely applied in agriculture is the expert system. An Expert System is a system designed to imitate or illustrate the expertise and knowledge of one or more experts, to provide alternative solutions to the problem to be solved.[1]

Expert systems have been used extensively in agriculture, including in the identification of diseases in crops. Using expert systems, farmers and agricultural experts can quickly and accurately identify diseases affecting crops and provide appropriate control measures. The advantages of using this expert system include speeding up the diagnosis process, reducing human error, increasing agricultural productivity, and optimizing the use of resources[2, 3, 4].

Based on previous research, several approaches have been taken in the development of expert systems for disease identification in plants. Methods such as fuzzy logic, [5] *Certainty Factor* [6], and *Forward Chaining* [7] have been used in various studies to address this problem. However, when compared to the Dempster-Shafer method, these approaches still have some limitations. Dempster-Shafer is a mathematical theory for proofs based on the functions of belief and reasonable thinking, used

to combine separate pieces of information (proofs) to calculate the probability of an event. In the context of disease identification in crops, uncertainty and lack of clear information often occur because the symptoms of the disease often overlap or are difficult to identify with certainty[8].

Using the Dempster-Shafer method, expert systems can combine different types of knowledge and provide a degree of confidence or confidence in any given diagnosis. This method can handle situations where there is vagueness or contradiction in the data or information provided. Therefore, the application of the Dempster-Shafer method in the expert system of disease identification in crop crops is expected to increase the accuracy and reliability of diagnosis results.

This research focuses on developing an expert system for disease identification in crop crops, using the Dempster-Shafer method. Despite previous research in this area, the application of the Dempster-Shafer method to crops is still rare. This study will collect and analyze data on disease symptoms, environmental factors, and control measures. This data will be classified that represent the types of diseases that are common in crop crops.

This expert system will be implemented in a web programming language, allowing farmers and agricultural experts to input observed symptoms. The Dempster-Shafer method will be used to calculate the diagnosis of possible diseases and provide recommendations for appropriate control measures. The goal is to help farmers and agricultural experts identify diseases more accurately and quickly take necessary action.

The novelty of the study lies in the application of the Dempster-Shafer method, which has not been widely used in this context. The results of this research are expected to increase the productivity and quality of crops, as well as open opportunities for the application of this method in other agricultural fields.

2. RESEARCH METHOD

2.1. Expert System

An expert system is a computer program that simulates the behavior of humans or organizations that have expert knowledge and experience in a particular field. Usually such systems contain a knowledge base containing accumulated experience and rules for applying basic knowledge to each specific situation. Expert systems are applied to support problem-solving activities, such as: Interpretation, Diagnosis, Design, Planning, Monitoring, Debugging, Instruction and Control. Another definition of expert systems is computer-based systems that use knowledge, facts and reasoning techniques in solving problems that can usually only be solved by an expert in a particular field. Here computers are used as a means to store the knowledge of experts [9, 10, 11].

2.2 Dempster-Shafer method

Dempster-Shafer is a mathematical theory for proof based on belief functions and plausible reasoning, which is used to combine separate pieces of information to calculate the probability of an event. The Dempster-Shafer method can be used to overcome the uncertainty factor in expert systems that causes many possible diagnoses to be found, by combining separate pieces of information to calculate the likelihood of an event based on a given confidence value. The sequence of the Dempster-Shafer method framework is shown in Figure 1 [12, 13].

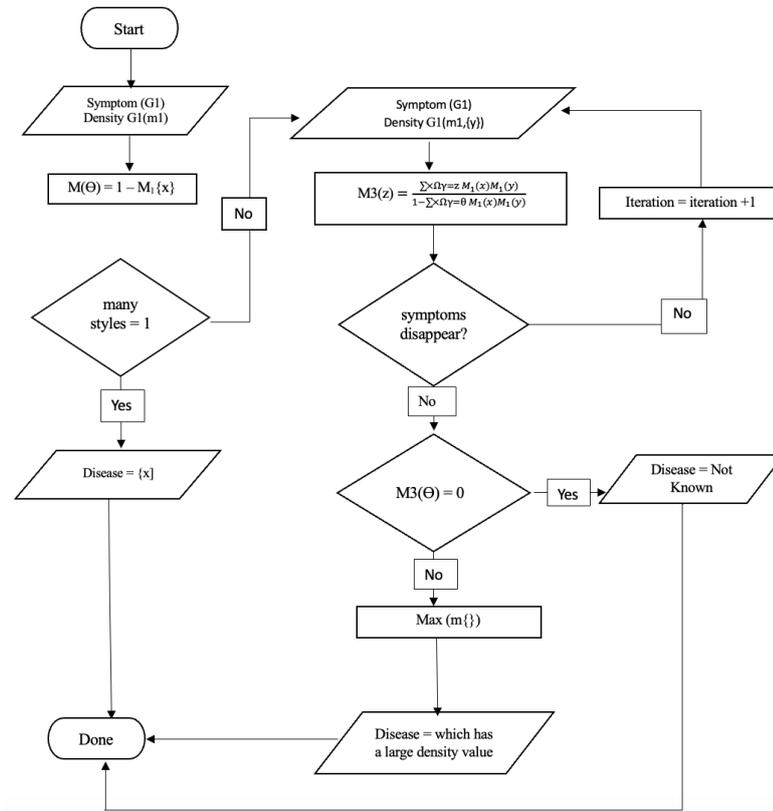


Figure 1. Working Steps of the Dempster-Shafer Method

2.3. Framework

In order for research to be more directed, easy to understand, the sequence of steps will be made systematically so that it can be used as a clear and easy guideline to solve existing problems. The sequence of steps to be made in this study can be seen in Figure 2.

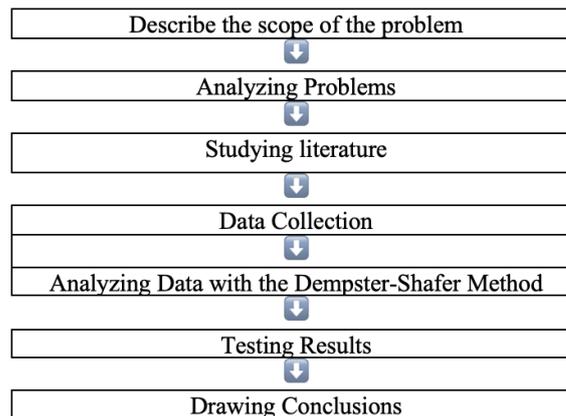


Figure 2. Framework

The explanation of the research flow above is as follows:

1. Describe the Scope of the Problem
The scope of the problem to be studied must first be determined, because if it is not able to define and determine the scope of the problem from a study, then the best solution will not be obtained. So the step of describing the scope of this problem is the most important first step in this writing.
2. Analyzing Problems
With problem analysis, it is expected to be able to understand the problem whose scope or limitations have been determined.
3. Studying literature

Literature study is an action carried out to study scientifically and theoretically the problems that have been limited previously sourced from journal literature related to research that can be accounted for.

4. Collecting Data

Collecting data is done by collecting all the data needed in research. The technique carried out for data collection in this study is by observation data calculation techniques.

5. Analyzing Data Using the Dempster-Shafer Method

To solve this problem use the Dempster-Shafer method in hopes of obtaining the appropriate *similarity* value based on the symptoms selected by the *user*.

6. Testing Results

Furthermore, testing was carried out on the developed data. Testing is carried out by applying the CBR Method based on existing criteria data. So that the level of system accuracy can be known by manual calculations.

7. Drawing Conclusions

Is the final stage of research, drawing conclusions based on literature studies and discussion of problems and is the result of analysis of research. The conclusion obtained is about the type of crop disease.

3. RESULTS AND DISCUSSION

In research on the identification of crop diseases using the Dempster-Shafer method which is a reasoning model that combines problem solving, understanding and learning as well as combining overall with memory processing [17]. The flowchart of the Dempster-Shafer process in this study is shown in Figure 1.

3.1 Research Data

The research data used are in the form of diseases of crops used as research objects, types of crops, diseases in each crop and also symptoms of each disease. To describe the completion of the methods used in this study and the knowledge gained from interviews with experts. So information is obtained in the form of knowledge and rules for the system to make a decision based on existing categories as in Table 1. Pests and Diseases. The processed data is a disease of corn crops.

Table 1. Pests and Diseases of Palawija Plants

No	KD Plant	Plant Name	Disease Code	Disease
1	TP01	Corn	JG1	Leaf Blight
			JG2	Leaf spot
			JG3	Rust
			JG4	Stem rot
			JG5	Anthracnose
			JG6	Root rot
			JG7	Cob rot
			JG8	Smut
			JG9	Virus Mosaic
			JG10	Nematodes
2	TP02	Taro	TL1	Root rot
			TL2	Leaf spot
			TL3	Taro mosaic
			TL4	Stem rot
			TL5	Anthracnose
			TL6	Tuber rot
			TL7	Root nematode
			TL8	Scabies Leaves
			TL9	Fusarium wilt
			TL10	Taro Yellow Virus
3	TP03	Long beans	KP1	Leaf spot

No	KD Plant	Plant Name	Disease Code	Disease
			KP2	Root rot
			KP3	String Bean Mosaic
			KP4	Anthracnose
			KP5	Stem rot
			KP6	Fusarium wilt
			KP7	Root nematode
			KP8	Yellow Virus
			KP9	Pod rot
			KP10	Rust
			4	TP04
OY2	Root rot			
OY3	Oyong Mosaic			
OY4	Anthracnose			
OY5	Stem rot			
OY6	Fusarium wilt			
OY7	Root nematode			
OY8	Yellow Virus			
OY9	Fruit rot			
OY10	Downy Mildew			
5	TP05	Potato	KT1	Leaf spot
			KT2	Root rot
			KT3	Potato mosaic
			KT4	Anthracnose
			KT5	Stem rot
			KT6	Fusarium wilt
			KT7	Root nematode
			KT8	Potato Yellow Virus
			KT9	Tuber rot
			KT10	Late Blight (Hawar Daun Akhir)
6	TP06	Siamese pumpkin	LS1	Leaf spot
			LS2	Root rot
			LS3	Siamese pumpkin mosaic
			LS4	Anthracnose
			LS5	Stem rot
			LS6	Fusarium wilt
			LS7	Root nematode
			LS8	Yellow Virus
			LS9	Fruit rot
			LS10	Downy Mildew

TP01: Corn

In this study, for the search process with the Dempster-Shafer method displayed symptoms on ornamental plants, especially on orchid plants which will be shown in Table 2.

Table 2. Symptoms of Pests and Diseases of Corn Plants

NO	Symptom Code	Symptomatic Name	Disease Code	WEIGHT
1	G01	White spots on leaves	JG1	0,22
2	G02	Young leaves are infected	JG1	0,24
3	G03	Yellowing leaves	JG1, JG6, JG9, JG10	0,17
4	G04	Wilted leaves	JG1, JG3, JG6, JG9	0,16
5	G05	Stunted plant growth	JG1, JG9	0,21
6	G06	Brown spot on leaves	JG2, JG3	0,19

7	G07	Purple spots on leaves	JG2	0,25
8	G08	Leaf rolling	JG2	0,18
9	G09	Leaves dry	JG2	0,21
10	G10	Leaf fall	JG2	0,17
11	G11	Brown spot on the stem	JG3	0,19
12	G12	Brown spot on cob	JG3	0,24
13	G13	Cobs do not develop	JG3	0,22
14	G14	Weak stem	JG4	0,18
15	G15	Stems break easily	JG4	0,16
16	G16	Stems blackish-brown	JG4	0,24
17	G17	Slimy stems	JG4	0,28
18	G18	Foul-smelling stems	JG4	0,14
19	G19	Black spots on the stem	JG5	0,23
20	G20	Black spot on leaves	JG5	0,21
21	G21	Perforated rod	JG5	0,23
22	G22	Root rot	JG6	0,22
23	G23	Weak plants	JG6	0,2
24	G24	The roots are blackish-brown	JG6	0,2
25	G25	Foul-smelling roots	JG6	0,17
26	G26	Slimy root	JG6	0,21
27	G27	Cob rot	JG7	0,24
28	G28	Cobs are black or red	JG7	0,17
29	G29	Cobs wither	JG7	0,22
30	G30	Foul-smelling cobs	JG7	0,18
31	G31	Slimy cobs	JG7	0,19
32	G32	Cobs swell	JG8	0,33
33	G33	Cobs containing fungal spores	JG8	0,21
34	G34	Cobs are black	JG8	0,29
35	G35	Foul-smelling cobs	JG8	0,17
36	G36	Leaf spotting	JG9	0,23
37	G37	Striped leaves	JG9	0,23
38	G38	Roots infected with nematodes	JG10	0,24
39	G39	Plants grow stunted	JG10	0,19
40	G40	Nodule root	JG10	0,23
41	G41	Wilted plants	JG10	0,17

In the Expert System the Inference Engine is the rule for fact matching. The inference engine starts its tracking by matching the facts in the knowledge base with rules that have been defined based on the Knowledge Base.

3.2 Symptom Input

The stages of selecting symptoms that appear in orchids, each is given weight based on the user's answer. If the answer is NO then weight = 0, if the answer is YES then the weight given depending on the weight of each symptom can be seen in Table 2.

Table 3. User Consulting

Symptom Code	Symptomatic Name	Answer
G01	White spots on leaves	YES
G03	Yellowing leaves	YES
G04	Wilted leaves	YES
G05	Stunted plant growth	YES
G08	Leaf rolling	YES

The formation of rules is a rule used by an expert system obtained from experts, where the experts in question are experts on pests and diseases of orchids. Here is the form of the rule obtained:

RULE 1 = IF G01 AND G02 AND G03 AND G04 AND G05 THEN P01

RULE 2 = IF G06 AND G07 AND G08 AND G09 AND G010 THEN P02

- RULE 3 = IF G04 AND G06 AND G11 AND G12 AND G13 THEN P03
- RULE 4 = IF G14 AND G15 AND G16 AND G17 AND G18 THEN P04
- RULE 5 = IF G03 AND G04 AND G19 AND G20 AND G21 THEN P05
- RULE 6 = IF G22 AND G23 AND G24 AND G24 AND G25 THEN P06
- RULE 7 = IF G27 AND G28 AND G29 AND G30 AND G31 THEN P07
- RULE 8 = IF G32 AND G33 AND G34 AND G35 THEN P08
- RULE 9 = IF G03 AND G04 AND G05 AND G36 AND G37 THEN P09
- RULE 10 = IF G03 AND G38 AND G39 AND G40 AND G41 THEN P10

After obtaining the rule from the expert, then the rule execution process is carried out based on the answer to the user's selected symptoms. The rule execution process is carried out by entering the symptom values of the user into the rule that has been set, then from these symptoms the minimum value of all symptoms that meet the rule is found then multiplied by the value of each rule.

a. Execution Rule 1 for TP01 disease

IF G01 AND G02 AND G03 AND G04 AND G05 THEN P01

G01 (YES = 0.22), then : $M1\{P1\} = 0.22$; $M1\{\emptyset\} = 1 - 0.22 = 0.78$.

G03 (YES = 0.17), then : $M2\{P1\} = 0.17$; $M2\{\emptyset\} = 1 - 0.17 = 0.83$.

	$M2\{P1\} 0.17$	$M2\{\emptyset\} 0.83$
$M1\{P1\} 0.22$	0,0374	0,1826
$M1\{\emptyset\} 0.78$	0,1326	0,6474

$M3\{P1\} = (0.037 + 0.1826 + 0.1326) / (1 - 0) = 0.3526$

$M3\{\emptyset\} = 0.6474 / 1-0 = 0.6474$

G04 (YES = 0.16), then : $M4\{P1\} = 0.16$; $M4\{\emptyset\} = 1 - 0.16 = 0.84$.

	$M6\{P1\} 0.16$	$M6\{\emptyset\} 0.84$
$M5\{P1\} 0.3522$	0,056352	0,295848
$M5\{\emptyset\} 0.6474$	0,10358	0,543816

$M5\{P1\} = (0.056352 + 0.10358 + 0.1326) / (1 - 0) = 0.488$

$M5\{\emptyset\} = 0.543816 / 1-0 = 0.543816$

G05 (YES = 0.21), then : $M6\{P1\} = 0.21$; $M6\{\emptyset\} = 1 - 0.21 = 0.79$.

	$M6\{P1\} 0.21$	$M6\{\emptyset\} 0.79$
$M5\{P1\} 0.488$	0,10248	0,38552
$M5\{\emptyset\} 0.543816$	0,11420136	0,42961464

$M7\{P1\} = (0.10248 + 0.38552 + 0.1142) / (1 - 0) = 0.6022$

$M7\{\emptyset\} = 0.42962 / 1-0 = 0.42962$

From the calculation above, the risk density value of late blight is 0.6022 or 60.22%.

b. Execution Rule 2 for TP02 disease

RULE 2 = IF G06 AND G07 AND G08 AND G09 AND G010 THEN P02

G08 (YES = 0.18), then : $M4\{P1\} = 0.18$; $M4\{\emptyset\} = 1 - 0.18 = 0.82$.

From the calculation above, the density value of risk of leaf spot is 0.18 or 18.00%.

c. Execution Rule 3 for TP03 disease

RULE 3 = IF G04 AND G06 AND G11 AND G12 AND G13 THEN P03

G04 (YES = 0.16), then : $M1\{P1\} = 0.16$; $M1\{\emptyset\} = 1 - 0.16 = 0.84$

For G11, G12 and G13 are not executed because the user's answer is NO. From the calculation above, the risk density value of Rust is 0.16 or 16%.

d. In rule 4 the execution of the rule is not done because all user answers are NO.

e. Execution Rule 5 for TP05 disease

IF G03 AND G04 AND G19 AND G20 AND G21 THEN P05

G03 (YES = 0.17), then : $M1\{P1\} = 0.17$; $M1\{\emptyset\} = 1 - 0.17 = 0.83$.

G04 (YA=0.16), then : $M2\{P1\} = 0.16$; $M2\{\emptyset\} = 1 - 0.16 = 0.84$.

	$M4\{P1\} 0.17$	$M4\{\emptyset\} 0.83$
$M3\{P1\} 0.22$	0,0374	0,1826

M3{θ} 0.78	0,1326	0,6474
------------	--------	--------

$$M3 \{P1\} = (0.0374 + 0.1826 + 0.1326) / (1 - 0) = 0.3526$$

$$M3 \{\theta\} = 0.6474 / 1-0 = 0.6474$$

In the symptoms of G19, G20 and G21 there is no need for processing because the answer is No. From this calculation, the risk density value of Anthracnose is 0.3526 or 35.26%.

- f. In rule 6 the execution of the rule is not done because all user answers are NO.
- g. In rule 7 the execution of the rule is not done because all user answers are NO.
- h. In rule 8 the execution of the rule is not done because all user answers are NO.
- i. Execution Rule 9 for TP09 disease

IF G03 AND G04 AND G05 AND G36 AND G37 THEN P09

G03 (YES = 0.17), then : $M1\{P1\} = 0.17$; $M1\{\theta\} = 1 - 0.17 = 0.83$.

G04 (YA=0.16), then : $M2\{P1\} = 0.16$; $M1\{\theta\} = 1 - 0.16 = 0.84$.

	M4{P1} 0.17	M4{θ} 0.83
M3{P1} 0.22	0,0374	0,1826
M3{θ} 0.78	0,1326	0,6474

$$M3 \{P1\} = (0.0374 + 0.1826 + 0.1326) / (1 - 0) = 0.3526$$

$$M3 \{\theta\} = 0.6474 / 1-0 = 0.6474$$

G05 (YES = 0.21), then : $M4\{P1\} = 0.21$; $M4\{\theta\} = 1 - 0.21 = 0.79$.

	M4{P1} 0.21	M4{θ} 0.79
M3{P1} 0.3526	0,074046	0,278554
M3{θ} 0.6474	0,135954	0,511446

$$M5 \{P1\} = (0.074046 + 0.278554 + 0.135954) / (1 - 0) = 0.488554$$

$$M5 \{\theta\} = 0.511446 / 1-0 = 0.511446$$

In the symptoms of G36 and G37 there is no need for processing because the answer is No. From this calculation, the risk density value of Mosaic Virus is 0.488554 or 48.554%.B

- j. Execution Rule 10 for TP10 disease

RULE 10 = IF G03 AND G38 AND G39 AND G40 AND G41 THEN P10

G03 (YES = 0.17), then : $M1\{P1\} = 0.17$; $M1\{\theta\} = 1 - 0.17 = 0.83$.

In symptoms G38, G39, G40 and G41 do not need to be processed because the answer is No. From this calculation, the value of the risk density of Nematodes is 0.17 or 17%.

From the results of the Dempster-Shafer Process, it was found that, Corn Plants can be identified as affected by disease and the risk of late blight, which is with a value of 0.6022 or 60.22%. This expert system diagnostic testing is carried out with randomized sample trials applied to test the appropriateness of symptoms and actual diagnosis. This test takes examples of orchid plants that have different types and symptoms of pests and diseases. The author tested 10 samples to conduct trials, after the trials produced 8 samples were properly exposed to pests and diseases according to the diagnosis which means the accuracy rate reached 80%. The results of this expert system diagnostic testing evaluation are shown in Table 4.

Table 4. Test Results

No	Sample	Diagnosis S.P	Data Real	Result
1	Sample 1	Leaf Blight	Leaf Blight	Valid
2	Sample 2	Leaf spot	Leaf spot	Valid
3	Sample 3	Rust	Rust	Valid
4	Sample 4	Stem rot	Stem rot	Valid
5	Sample 5	Leaf Blight	Leaf spot	Invalid
6	Sample 6	Root rot	Root rot	Valid
7	Sample 7	Cob rot	Cob rot	Valid
8	Sample 8	Smut	Smut	Valid
9	Sample 9	Virus Mosaic	Virus Mosaic	Valid
10	Sample 10	Leaf Blight	Stem rot	Invalid

4. CONCLUSION

Based on the stages of research and analysis that have been carried out, it can be concluded that this expert system is effective in tracing the symptoms of disease in corn plants observed by users. Symptoms identified include white spots on leaves, yellowing of leaves, wilting of leaves, stunted plant growth, and leaf rolling. The identification results showed the percentage of presence of various types of diseases, with Leaf Blight having the highest density of 60.22%. In the comparison between identification by experts and expert systems, there are two differences in sample 5 and sample 10. Therefore, the accuracy rate of expert systems using the Dempster-Shafer method is 80%. This suggests that this expert system is feasible for use in the identification of diseases in maize crops.

REFERENCES

- [1] D. Aldo, "Expert System For Initial Identification Of Diseases Caused By Helicobacter Pylori Bacteria Using Case Based Reasoning Approach," *Jurnal Teknik Informatika (JUTIF)*, vol. 4, no. 1, pp. 67–75, Feb. 2023, doi: 10.20884/1.jutif.2023.4.1.693.
- [2] B. A. Krisnamurti, Y. D. Prasetyo, and C. Kartiko, "Expert System of Land Suitability for Fruit Cultivation Using Case-Based Reasoning Method," *2021 IEEE International Conference on Communication, Networks and Satellite (COMNETSAT)*, pp. 38–44, Jul. 2021, doi: 10.1109/COMNETSAT53002.2021.9530782.
- [3] M. F. I. M. Idris, K. A. A. Aziz, and N. E. M. Shaharuddin, "The Recognition of MD2 Pineapple's Grade in Malaysia using Fuzzy Expert Systems," *2022 2nd International Conference on Electronic and Electrical Engineering and Intelligent System (ICE3IS)*, pp. 7–11, Nov. 2022, doi: 10.1109/ICE3IS56585.2022.10010021.
- [4] D. Aldo, Y. S. R. Nur, A. C. F. Lanyak, F. Y. A. Hulqi, and R. N. Hikmah, "Penerapan Metode Case Base Reasoning Dalam Diagnosa Penyakit dan Hama pada Tanaman Hortikultura," *Building of Informatics, Technology and Science (BITS)*, vol. 4, no. 2, Sep. 2022, doi: 10.47065/bits.v4i2.1888.
- [5] N. Astuti Hsb, "Perancangan Aplikasi Sistem Pakar Mendiagnosa Penyakit Pada Tanaman Hias Dengan Menggunakan Metode Fuzzy Logic," *Jurnal Pelita Informatika*, vol. 8, no. 1, pp. 78–83, 2019.
- [6] M. Faried, G. El Mirzaq, and R. Helilintar, "Sistem Pakar Diagnosa Penyakit Tanaman Tomat Menggunakan Metode Certainty Factor," *Seminar Nasional Inovasi Teknologi*, pp. 230–235, 2021.
- [7] Rozi Irnaldi, "Sistem Pakar Diagnosa Penyakit Tanaman Cabai Menggunakan Metode Forward Chaining Berbasis Android," *JuuPerSaTeK*, vol. 2, no. 1, pp. 165–174, 2019.
- [8] K. Kraugusteeliana, N. Putra, M. D. Yuniar, D. Aldo, A. Rahmawati, and V. D. Saputra, "Detection of Ovarian Cancer Risk Level Using the Web-Based Dempster Shafer Method," in *2022 International Conference on Informatics, Multimedia, Cyber and Information System (ICIMCIS)*, IEEE, Nov. 2022, pp. 365–369. doi: 10.1109/ICIMCIS56303.2022.10017624.
- [9] H. MULYONO, R. A. DARMAN, and G. RAMADHAN, "Sistem Pakar Diagnosa Kerusakan Pada Laptop Menggunakan Metode Certainty Factor," *JUPI (Jurnal Ilmiah Penelitian dan Pembelajaran Informatika)*, vol. 5, no. 2, p. 98, 2020, doi: 10.29100/jipi.v5i2.1708.
- [10] Y. Wijayana, "Sistem Pakar Kerusakan Hardware Komputer Dengan Metode Backward Chaining Berbasis Web" *Media ElektriKa*, vol. 12, no. 2, 2019, [Online]. Available: <http://jurnal.unimus.ac.id>

-
- [11] I. Wulandari, "Sistem Pakar Talenta Implementasi Kecerdasan Buatan Dalam Pelayanan Publik Menuju Sragen Smart City," *LITBANG SUKOWATI*, vol. 2, no. 1, pp. 75–88, 2018.
- [12] K. Arifin, A. N. Nafisa, E. N. D. Br Purba, N. A. Putri, K. S. S, and D. Y. Niska, "Sistem Pakar Diagnosa Penyakit Kulit Kucing Dengan Metode Dempster Shafer," *Jurnal Informatika*, vol. 10, no. 1, pp. 85–91, Apr. 2023, doi: 10.31294/inf.v10i1.14488.
- [13] I. Istiadi, Emma Budi Sulistiarini, Rudy Joegijantoro, and Dedi Usman Effendy, "Infectious Disease Expert System Using Dempster Shafers With Recommendations for Health Services," *Jurnal RESTI (Rekayasa Sistem dan Teknologi Informasi)*, vol. 4, no. 1, pp. 17–27, Feb. 2020, doi: 10.29207/resti.v4i1.1332.