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Forward Chaining Method in Expert System for Diagnosing Pests and Plant Diseases: A Systematic Literature Review

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Abstract

Pest and disease attacks on plants are very detrimental factors for farmers. Lack of knowledge leads to a difficult diagnosis of attacks and slow control. The technology that can help farmers in diagnosing plant pests and diseases is the expert system. One of the most widely used algorithms is forward chaining. Although there have been many used further research is needed to determine the effectiveness of this method. This research wants to find out more advantages, types of platforms used, and benefits of expert systems with forward chaining algorithms. This study uses a systematic method literature review (SLR) to collect, assess, and analyze data systematically from various scientific articles. The results of the study show that the use of forward chaining has advantages and benefits for developers and farmers.

Keywords: *Forward Chaining, Expert System, Pests, Plant Diseases, Systematic Literature Review*

1. Introduction

The increasing demand for food along with the growth of the population is a challenge for the agricultural sector in increasing the effectiveness and productivity of agricultural products [1] The productivity of agricultural products is often constrained due to pest and disease attacks on plants that are difficult to identify at the beginning [2]. The limited knowledge of farmers and the lack of availability of experts around encourage the use of technology through the application of an expert system. An approach that has been widely carried out in the expert system of diagnosing pests and diseases in plants is the forward chaining method [3].

Forward chaining is one of the inference techniques in artificial intelligence that works by starting from the known facts and applying relevant rules to produce the conclusion. In the context of agriculture, forward chaining can be applied to analyze the symptoms seen in plants and provide a precise diagnosis of the type of pests or diseases that attack the plant. The use of the forward chaining method in the pests and diseases diagnosis expert system can help farmers and agronomists in detecting pest and disease attacks early so that control action can be carried out quickly and effectively [4].

This study aims to analyze the use of the forward chaining method in diagnosing pests and plant diseases through the Systematic Literature Review (SLR) approach. With the SLR method, researchers summarize, assess, and analyze various studies that have been carried out in this field to evaluate the forward chaining method for the diagnosis of pests and plant diseases to obtain a more comprehensive understanding of the advantages, platforms, and benefits of the system created.

2. Research Methods

This research uses Systematic Literature Review (SLR) as a technique to collect, evaluate, and synthesize data systematically from various sources of scientific literature from a literature database with more objective and accountable results. Procedures for systematic literature involve several steps, including defining the research question, identifying the search process, defining the inclusion and exclusion criteria, quality assessment, collecting data, and analyzing data based on the mentioned before [5].

2.1. Research Question

Based on the topic chosen as a study in SLR, the research question is formulated as the main question or focus of the research to help guide the research process and determine the limits and objectives of the research. The research questions in this study are:

1. RQ1 = What are the advantages of the forward chaining method for the diagnosis of pests and plant diseases?
2. RQ2 = What platform is often used to build the system using the forward chaining method?
3. RQ3 = Does the system designed with the forward chaining method provide benefits to users in diagnosing pests and diseases in plants?

2.2. Search process

The search process is used to find relevant sources to answer the research question (RQ) and other related references. The search process in this study uses the Microsoft Bing search engine by accessing https://garuda.kemendikbud.go.id/ site as primary data and Harzing Publish or Perish software as secondary data.

2.3. Inclusion and Exclusion Criteria

The determination of inclusion and exclusion criteria were used to ascertain whether the data was found appropriate in the SLR study. This research is considered appropriate if it meets the following criteria:

1. The relevant journals published within the last 5 years (2020-2024)
2. Journals are obtained from the Garuda Kemendikbud through the URL https://garuda.kemendikbud.go.id/
3. The data used is limited to the use of the forward chaining method for pest and plant diseases without any combination with other methods.
4. Application of the forward chaining method in the expert system

The exclusion criteria include:

1. Journals that do not use forward chaining to diagnose pests and plant diseases
2. Journals that user forward chaining method with a combination of other methods
3. Journals that do not meet the specified keyword criteria

2.4. Quality Assessment

Quality Assessments are needed to determine the quality of journals. Journals found will be assessed with the following evaluation criteria.

QA1. Was the journal published between 2020-2024?
QA2. Does the journal discuss the diagnosis of various pests and plant diseases with the forward chaining method on the expert system?
QA3. Does the journal discuss the platform used in the application of the forward chaining method for the diagnosis of pests and plant diseases

Each journal will be assessed based on the QA criteria above, namely:

1. Y (Yes), if the selected journal meets the QA criteria
2. T (No) if the selected journal does not meet the QA criteria

2.5. Data Collection

In this study, the data collected was divided into two, namely primary data and secondary data. Primary data refers to information obtained directly such as surveys, observations, interviews and so on that are adjusted to the needs of researchers. Primary data in this study were obtained from journals accessed through the http://garuda.kemendikbud.go.id/. This study uses Garuda Kemendikbud because it is suitable for the needs of researchers which has filtering features based on period and search based on keywords relevant to the research topic. Secondary data is complementary to primary data if primary data cannot display complete information. This is obtained by using Harzing Publish or Perish software because it can directly redirect to the journal article page and can read the full version. The data collection process in this study is carried out through observation the source provided by https://garuda.kemendikbud.go.id/ with the following stage:

1. Access the URL https://garuda.kemendikbud.go.id/ through the Microsoft Bing search engine
2. Enter the keyword "forward chaining hama dan penyakit tanaman" and filter by year (2020-2024) as shown in the following figure.

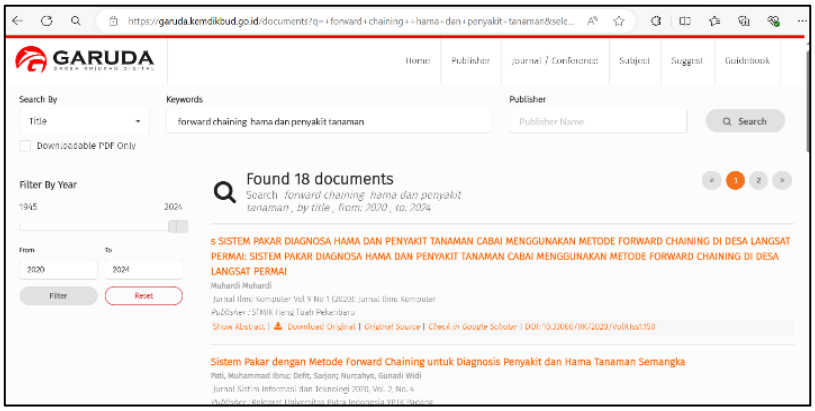

Fig. 1: Search result on https://garuda.kemendikbud.go.id/ using keywords "forward chaining hama dan penyakit tanaman" and year filtering bt 2020-2024

2.6. Analysis

At this stage, the data obtained is analyzed to gain understanding and knowledge related to the information needed. Data is analyzed to prove and answer the research question (RQ):

1. Advantages of the forward chaining method for the diagnosis of pests and plant diseases (refer to RQ1)
2. A platform that is often used in the application of the forward chaining method diagnosing pests and plant diseases (refer to RQ2)
3. Forward chaining method to diagnosis pests and plant diseases provides benefits to users (refer to RQ3)

3. Result and Discussion

3.1. Search Process Result

The result of the search process on https://garuda.kemendikbud.go.id/ based on keywords and year filtering resulted in 18 journals that are relevant to the topic researched.

3.2. Inclusion and Elusion Criteria Result

After going through the search stage, the journals that were successfully displayed were filtered again based on inclusion and exclusion criteria. The results showed that of the 18 journals found at the beginning, 13 journals were left that met the set criteria

3.3. Data Collection and Quality Assessment Result

Journals that have been successfully collected and passed the inclusion and exclusion criteria then assessed based on the predetermined quality assessment. The results of the quality assessment are shown in the following table

Table 1: Data Collection and Quality Assessment Result

No	Details				Result
1	Title	Expert System for Diagnosing Pests and Diseases of Chili Plants Using the Forward Chaining Method in Langsat Permai Village: Expert System for Diagnosing Pests and Diseases of Chili Plants Using the Forward Chaining Method in Langsat Permai Village [6]			√
	Authors	Muhardi, Anita Febriani,Hariwanda			
	Journals/year	Jurnal Ilmu Komputer Vol 9 No 1 (2020)			
	Quality Assessment	**QA1**	**QA2**	**QA3**	
		Y	**Y**	**Y**	
2	Title	Expert System with Forward Chaining Method for Diagnosis of Watermelon Plant Diseases and Pests			√
	Authors	M. Ibnu Pati, Sarjon Defit , Gunadi Widi Nurcahyo[7]			
	Journals/year	Jurnal Sistem Informasi dan Teknologi (JSISFOTEK) 2020, Vol. 2, No. 4 2020			
	Quality Assessment	**QA1**	**QA2**	**QA3**	
		Y	**Y**	**Y**	
3	Title	Implementation of a Mobile-Based Expert System to Diagnose Pests and Diseases of Pineapple Plants Using the Forward Chaining Method [8]			√
	Authors	Nurmayanti, Rendi Saputra			
	Journals/year	JSK (Jurnal Sistem Informasi dan Komputerisasi Akuntansi) Vol 4 No 2 (2020): Juli 2020			
	Quality Assessment	**QA1**	**QA2**	**QA3**	
		Y	**Y**	**Y**	
4	Title	Application of Forward Chaining Method to Identify Pests and Diseases of Rice Plants (Case Study: Purworejo Village, Kotagajah District, Central Lampung Regency) [9]			**X**
	Authors	Muhammad Nur Ikhsanto; Mr. Sulistiyanto; Lulu Nafisa			
	Journals/year	International Research on Big-Data and Computer Technology: I-Robot Vol 5 (2021): September 2021			
	Quality Assessment	**QA1**	**QA2**	**QA3**	
		Y	**Y**	**T**	
5	Title	Creation of an Expert System to Diagnose Pest Diseases in Cocoa Plants Using the Forward Chaining Method [10]			√
	Authors	Asri, Rahmawati Nasser			
	Journals/year	Jurnal Ilmiah Information Technology d'Computare Vol 11 No 1 (2021): Edisi Januari 2021			
	Quality Assessment	**QA1**	**QA2**	**QA3**	
		Y	**Y**	**Y**	
6	Title	Aglaonema pests and Plant Disease Identification System Using Web-Based Forward Chaining Method [11]			√
	Authors	Hilda Tasya Salsabila; Lily Wulandari; Dini Tr			
	Journals/year	Jurnal Ilmiah Informatika Komputer Vol 27, No 2 (2022			
	Quality Assessment	**QA1**	**QA2**	**QA3**	
		Y	**Y**	**Y**	
7	Title	Expert System for Diagnosing Pests and Diseases in Kale Plants Using the Forward Chaining Method [12]			√
	Authors	Iffan Ahmad Nasrulloh; Pradana Ananda Raharja; Amalia Beladinna Arifa			
	Journals/year	Jurnal SAINTEKOM Vol. 12 No. 2 (2022): September 2022			
	Quality Assessment	**QA1**	**QA2**	**QA3**	
		Y	**Y**	**Y**	
8	Title	Expert System Expert System for Diagnosis of Pests and Diseases of Bonsai Plants Using the Forward Chaining Method [13]			√
	Authors	Ismiya Nurhayati; Sri Lestanti; Saiful Nur Budiman			
	Journals/year	Jurnal Algoritme Vol 3 No 1 (2022)			
	Quality Assessment	**QA1**	**QA2**	**QA3**	
		Y	**Y**	**Y**	
9	Title	Expert System for Diagnosing Diseases and Pests of Oil Palm Plants with Forward Chaining Method			√
	Authors	Alzena Dona Sabilla; Syamsul Ma'arif [14]			
	Journals/year	Journal of Economic, Business and Engineering (JEBE) Vol 4 No 1 (2022): Oktober			
	Quality Assessment	**QA1**	**QA2**	**QA3**	
		Y	**Y**	**Y**	
10	Title	Expert System for Diagnosis of Diseases and Pests in Rice Plants with Forward Chaining Method [15]			√
	Authors	Vit Zuraida; Deddy Kusbianto; Mohammad Reza Pahlevi			

No	Details				Result
	Journals/year	Jurnal Minfo Polgan Vol. 12 No. 1 (2023)			
	Quality Assessment	**QA1**	**QA2**	**QA3**	
		Y	**Y**	**Y**	
11	Title	Expert System with Forward Chaining Method for Diagnosis of Sugarcane Plant Diseases and Pests [16]			√
	Authors	Andre Rahmat Kurniawan; Gunadi Dwi Nurcahyo; Yuhandri			
	Journals/year	INTEK : Jurnal Informatika dan Teknologi Informasi Vol. 6 No. 1 2023			
	Quality Assessment	**QA1**	**QA2**	**QA3**	
		Y	**Y**	**Y**	
12	Title	Expert System for Diagnosing Tomato Plant Pests and Diseases Using the Forward Chaining Method [17]			√
	Authors	Alberta Mbagho; Meliana O. Meo; Gregorius Rinduh Iriane			
	Journals/year	JURNAL SAINS DAN KOMPUTER Vol. 7 No. 01 (2023): Jurnal Sains dan Komputer			
	Quality Assessment	**QA1**	**QA2**	**QA3**	
		Y	**Y**	**Y**	
13	Title	Android-Based Expert System for Diagnosing Pests and Diseases of Chili Plants with Forward Chaining Method [18]			√
	Authors	Suradi; Syarifuddin Baco; Bowasis Umar; Murdianto; Siti Trisnayanti Sri Rezky Simamora			
	Journals/year	Jurnal Teknologi dan Komputer (JTEK) Vol. 3 No. 01 (2023): JUNI			
	Quality Assessment	**QA1**	**QA2**	**QA3**	
		Y	**Y**	**Y**	

Note:
√ : the journal was chosen to be used in the research because it has relevance to the problem, approach, and information needed to answer the RQ
X : the journal was not selected to continue at the analysis stage because there were quality assessment criteria that were not met and could not represent the necessary data.

Based on the results of the quality assessment, of the 13 journals that passed the inclusion and exclusion criteria, only 12 were accepted to continue at the following stage. One journal was rejected because it did not meet one of the quality assessment criteria, namely there was no information about the platform used.

3.4. Analysis Data Result

After obtaining journals that meet all criteria, then all the data is carried out to analyze. The results of the data analysis are described in the following table:

Table 2: Data Analysis Result

Authors	Advantages	Platform	Benefits
Muhardi, Anita Febriani,Hariwanda	New data can be inserted into the inference database table and allow for inference rule changes to be made	Web	1. Able to make an initial diagnosis of a disease and pest and proposed solutions to overcome the disease. 2. Assist users in obtaining information about diseases and pests that are often experienced by chili plants and solutions to deal with them 3. Helping chili farmers to know the diseases and pests experienced by their chili plants without having to call an expert
M. Ibnu Pati, Sarjon Defit , Gunadi Widi Nurcahyo	It is widely applied in agriculture because of the efficiency of time in the search for inference.	Web	1. Produce accuracy in diagnosing pests and diseases of watermelon plants 2. Web-based and accessible online from anywhere 3. Information and consultation can be done without meeting with an expert
Nurmayanti, Rendi Saputra	can be modified by adding new rules as knowledge and ease to implementation in mobile platform	Mobile	This system helps the agriculture department and farmers understand the types of pests and diseases in pineapple plants
Asri, Rahmawati Nasser	ease of implementation in a rules-based system	Mobile	Easy access because farmers can directly access the application and obtain the desired information through Android devices
Hilda Tasya Salsabila; Lily Wulandari; Dini Tr	The reasoning carried out is by what Aglaonema plant experts do in identifying pests and diseases	Web	Helping users to carry out the process of identifying pests and diseases easily, users can get solutions to overcome pest and disease attacks without having to meet with an expert.
Iffan Ahmad Nasrulloh; Pradana Ananda Raharja; Amalia Beladinna Arifa	Suitable for conditions where initial data is readily available and a diagnosis or solution will be sought	Web	The system can diagnose diseases and pests in kale through the symptoms experienced by farmers and help farmers and the community in controlling pests and diseases in kale plants properly and correctly and correctly.
Ismiya Nurhayati; Sri Lestanti; Saiful Nur Budiman	can be modified by adding new rules without changing the basic structure of the existing system	Web	The system that is built provides benefits to users because it is able to present accurate diagnoses
Alzena Dona Sabilla; Syamsul Ma'arif	The effectiveness of the prosecution process that begins by displaying a	Web	It makes it easier for farmers to know oil palm plant diseases because it saves time to find out the solution directly.

Authors	Advantages	Platform	Benefits
	convincing set of data or facts towards the final condition		
Vit Zuraida; Deddy Kusbianto; Mohammad Reza Pahlevi	Ease of adding rules to inference tables	Web	Providing convenience for rice farmers with an accuracy rate of 87.4%
Andre Rahmat Kurniawan; Gunadi Dwi Nurcahyo; Yuhandri	Widely applied to the expert system in the field of agriculture	Web	Produces accurate diagnoses that make it easier for users to identify sugarcane pests and diseases
Alberta Mbagho; Meliana O. Meo; Gregorius Rinduh Iriane	forward chaining method has ease of implementation in a rule-based system	Web	assist the government and the community in the process of checking pest and disease data on tomato plants at the Kupang City Agriculture Office and the system built can help users in diagnosing tomato plant diseases at the Kupang City Agriculture Office
Suradi; Syarifuddin Baco; Bowasis Umar; Murdianto; Siti Trisnayanti Sri Rezky Simamora	Suitable for use in systems that require real-time response	Mobile	Providing convenience and helping farmers carry out early control so as to prevent losses

RQ1 = What are the advantages of the forward chaining method for the diagnosis of pests and plant diseases?
Overall, from the 12 journals analyzed, it was found that the forward chaining method for diagnosing pests and plant diseases has several advantages, namely:

1. Direct premise reasoning process
   In the Forward chaining method, the process of reasoning the premise or inference starts from the known facts and goes directly to the conclusion, so this method is suitable for conditions where initial data is already available and a diagnosis or solution will be sought.
2. Ease of implementation
   The forward chaining method has ease of implementation in a rule-based system because this method can work in a simple way, namely by matching existing rules with available facts
3. Responsiveness to new data
   The forward chaining method can update the conclusions generated when information is added with new data without the need to reprocess the data from scratch
4. Suitable for real-time systems
   The forward chaining method is very suitable for use in systems that require real-time response, such as in smart agriculture applications that monitor plant conditions directly.
5. Scalability
   The forward chaining method can be modified by adding new rules as knowledge about pests and diseases develops without changing the basic structure of the existing system

RQ2 = What platform is often used to build the system using the forward chaining method?
Of the 12 journals analyzed, the application by platform is shown in the following table:

Table 3: Grouping by platform used

No	Platforms used	Amount
1.	Website	9
2.	Mobile Application	3

The website is the most widely used platform in the application of the forward chaining method in the expert system of diagnosing pests and plant diseases in this study. Website pages provide easy access to users through various internet-connected devices such as PCs, laptops and smartphones. However, in some journals recommended to design on a mobile application for further development considering the efficiency and user interface that is simpler and more attractive in the mobile version. In addition, the development of the mobile version allows easy access to the camera to take images of plants that are infested with pests and diseases

RQ3 = Does the system designed with the forward chaining method provide benefits to users in diagnosing pests and diseases in plants?

Based on the results of the data analysis shown in Table 2, it can be concluded that the forward chaining method applied to the expert system of diagnosis of pests and plant diseases has benefits, especially in terms of ease and accuracy in diagnosing pests and diseases. All journals reviewed in this study showed an accuracy level above 85%.

4. Conclusion

Based on the results of the SLR in this study conducted in journals published in Garuda from 2020-2024, the Forward chaining has the advantage of being applied to development of expert systems. The higher the quality of the data and the amount of knowledge that comes in, the more accurate the system will be. Expert systems with forward chaining methods are widely developed on web-based platforms, but with the development of mobile device technology this method is also starting to be developed in mobile platforms. This forward chaining method is easy to implement and combined with other methods to improve the reliability of the system.

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