JURNAL TEKNOLOGI DAN OPEN SOURCE
Vol. 8, No. 1, June 2025, pp. 288~294
e-ISSN: 2622-1659, accredited Four Grade by Kemenristekdikti, Decree No: 152/E/KPT/2023
DOI: 10.36378/jtos.v8i1.4416

Rule-Based Expert System Model with Backward Chaining Algorithm for Symptom-Based Skin Disease Diagnosis

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Article Info

Article history:

Received 05 27, 2025
Revised 06 03, 2025
Accepted 06 18, 2025

Keywords:

Backward Chaining
Clinical Diagnosing
Expert System
Inference Algoritm
Skin Disease

ABSTRACT

A rule based expert system is one which emulates the expert system decision making process through a knowledge base with applied inference algorithms. This research created a rule based expert system model with backward chaining algorithm for the diagnosis of skin diseases through the patient's clinical symptoms. Backward chaining is a goal driven inference that starts with the hypothesis of a certain disease (e.g. psoriasis) and checks for relevant symptoms, confirming observable indicators of the condition (kemerahan, sisik keperakan), making it easy to differentiate skin disorders which have overlapping symptoms like dermatitis, psoriasis and scabies. The model was proficient in managing ambiguity, diagnosed correctly, and verified symptoms interactively. It was developed from credible sources like WHO and AAD which formed the model's knowledge base intended to aid clinical decision support systems. The results indicated that the application of backward chaining algorithms yielded improvements on the accuracy and efficiency for the diagnosis of skin diseases through the reported symptoms by the patients.

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1. Introduction

An expert system simulates the decision-making capabilities of a human specialist by utilizing a predefined knowledge base and applying reasoning processes to solve specific problems within a given area. Expert systems are most helpful in situations where human experts are hard to come by, very costly to engage, or when their skills are in great supply and demand[1]. Expert systems are also useful in situations where critical judgment needs to be made in hostile or complicated situations. Despite the long-standing developments in the field, the expert system approach continues to be useful in many areas of science and technology[2]. As an example, skin diseases in medicine is a noteworthy challenge, because many diseases of this category share a large number of symptoms[3]. The patients suffering from these disorders, like eczema (atopic dermatitis), psoriasis, and seborrheic dermatitis, each of which has differing causes and treatment modalities, often face similar difficulties [4]. Consulting a specialist is a must, because many skin diseases with comparable symptoms often masquerade numerous other conditions, making it extremely difficult to accurately pinpoint the disease[5][6]. As an example, scabies and atopic dermatitis both show widespread rashes and severe itching, particularly at night[7]. An additional instance pertains to cancer patients' symptoms of Herpes Simplex Virus (HSV) and Varicella Zoster Virus (VZV) infections, which tend to be very difficult to differentiate because of their vague, non-specific, and fluctuating resemblance to other

problems[8][9]. The clinical distinctions between scabies and atopic dermatitis are often ambiguous, making it challenging for laypersons to accurately diagnose the condition [7]. The backward chaining method is an inference strategy in expert systems that begins with a hypothesis and subsequently traces and verifies facts that support it [10][11]. This means the system will ask a series of questions or gather relevant information to confirm whether the hypothesis is accurate[12].

This study aims to help individuals identify their skin conditions using an expert system that applies the backward chaining method, relying on symptoms and related hypotheses. Based on test case validations, the rule-based expert system developed in this research achieved an accuracy rate of 75%, showing promising potential for accurately and efficiently diagnosing skin diseases through clinical symptoms.

1.1 Knowledge Acquisition Mechanism

Expert systems rely on a knowledge base as a core component to function effectively [13][14]. The knowledge acquisition phase involves collecting technical documents and credible sources—such as reports, photographs, previous research, and other references—while also regularly consulting with experts[15]. Knowledge should be gathered from trustworthy sources, such as experts or reputable references. In this study, the knowledge base was built using clinical guidelines from the World Health Organization (WHO), dermatology protocols, and peer-reviewed scientific journals.

1.2 Knowledge Base

The core of an expert system is its knowledge base, which holds domain-specific information in the form of facts and structured rules[16][17]. This component consists of a set of rules developed through reasoning based on previously gathered data. These rules are usually expressed as inference statements in an IF-THEN format[18]. A knowledge base is a collection of information that's organized in a structured and interconnected way, often represented as a semantic network. This network shows how different concepts are related to one another. Its structure is built on frames—data structures designed to hold details about specific concepts[19]. Symptom data and diagnostic rules gathered during the knowledge acquisition process are organized into a knowledge base. This knowledge base is then used by the expert system to support backward chaining inference for diagnosing based on clinical symptoms.

1.3 Inference Engine

The inference engine is one of the main parts of an expert system model that influences its performance[20]. The inference engine applies rules to known facts in order to derive new facts. It may also possess the capability to explain and troubleshoot the reasoning process[21]. The inference engine used in this model is Backward Chaining. Backward Chaining is an inference method that works by starting from a goal or hypothesis and moving backwards to verify whether the existing data support that goal[22].

1.4 Explanation Mechanism

The explanation mechanism is the final step that exposes the diagnostic logic by referring to the IF-THEN rules in the knowledge base and the backward chaining inference step to help the user understand the reasoning behind a given decision[23]. The explanation mechanism stores information about how the inference engine reaches its conclusions. Based on this information, it explains how the inference engine arrives at the results provided to the user[24]

2. Research Method

A. Knowledge Acquisition Mechanism

This knowledge was then expressed as IF–THEN rules, which form the basis of a rule-based expert system model using the Backward Chaining inference method. The data included 30 different skin diseases along with their symptoms, many of which had overlapping characteristics.

B. Knowledge Base

This study implements the Backward Chaining method, in which the reasoning process begins with a hypothesis derived from a knowledge base consisting of 30 types of skin diseases, many of which exhibit similar symptoms. he model then analyzes the symptoms provided by the user, tracing them step by step to determine whether they align with the existing data in the knowledge base. This process helps assess the accuracy of the user's initial hypothesis and ensures that the diagnosis is supported by relevant

clinical evidence. If the identified symptoms are more consistent with a different disease, this suggests that the initial hypothesis is incorrect.

Table 1. Knowledge Base

No	Disease	Symptoms (IF)	Diagnose (THEN)
1.	Psoriasis	Kemerahan, sisik keperakan, gatal	Psoriasis
2.	Dermatitis Atopik	Gatal intens, vesikel, kulit kering	Dermatitis Atopik
3.	Scabies	Gatal intens, lesi malam hari, papula	Scabies
4.	Dermatitis Kontak	Kemerahan, gatal, vesikel, pembengkakan	Dermatitis Kontak
5.	Ekzema	Gatal, kemerahan, kulit bersisik	Ekzema
6.	Impetigo	Pustula, krusta kuning, kemerahan	Impetigo
7.	Herpes Zoster	Vesikel unilateral, nyeri, kemerahan	Herpes Zoster
8.	Herpes Simplex	Vesikel berkelompok, kemerahan, rasa terbakar	Herpes Simplex
9.	Tinea Corporis	Gatal, kemerahan, lesi annular	Tinea Corporis
10.	Tinea Pedis	Gatal, kulit bersisik, kemerahan di kaki	Tinea Pedis
11.	Tinea Cruris	Gatal, kemerahan, lesi di lipat paha	Tinea Cruris
12.	Candidiasis Kulit	Kemerahan, gatal, pustula di area lembab	Candidiasis Kulit
13.	Rosacea	Kemerahan wajah, papula, pustula	Rosacea
14.	Acne Vulgaris	Komedo, papula, pustula, nodul	Acne Vulgaris
15.	Folikulitis	Papula, pustula di folikel rambut, gatal	Folikulitis
16.	Pityriasis Rosea	Lesi oval, sisik halus, gatal ringan	Pityriasis Rosea
17.	Pityriasis Versicolor	Bercak hipopigmentasi, sisik halus, gatal ringan	Pityriasis Versicolor
18.	Lichen Planus	Papula ungu, gatal, lesi polygonal	Lichen Planus
19.	Urticaria	Bilur gatal, kemerahan, pembengkakan sementara	Urticaria
20.	Melanoma	Asimetri, tepi tidak rata, perubahan warna, diameter > 6mm	Melanoma
21.	Basal Cell	Nodul mengkilap, ulserasi, kemerahan	Basal Cell
22.	Carcinoma Cellulitis	Kemerahan, pembengkakan, nyeri, demam	Carcinoma Cellulitis
23.	Furunkel	Nodul nyeri, pustula, kemerahan	Furunkel
24.	Vitiligo	Bercak hipopigmentasi, tanpa gatal, batas jelas	Virtiligo
25.	Abses Kulit	Pembengkakan, nyeri, pus, kemerahan	Abses Kulit
26.	Squamous Cell Carcinoma	Plak keras, ulserasi, kemerahan	Squamous Cell Carcinoma
27.	Verruca Vulgaris (Kutil)	Papula kasar, permukaan keras, nyeri ringan	Verruca Vulgaris (Kutil)
28.	Molluscum Contagiosum	Papula berkilau, pusat cekung, tidak gatal	Molluscum Contagios
29.	Eritema Multiforme	Lesi target, kemerahan, gatal ringan	Eritema Multiforme
30.	Seborrheic Dermatitis	Sisik berminyak, kemerahan, gatal di kulit kepala	Seborrheic Dermatitis

C. Inference Engine

Figure: Backward Chaining Mechanism in Expert Systems. The backward chaining mechanism is a reasoning method used in expert systems that starts with a specific goal and works backward to check if the available facts support it. In medical diagnostics, for example, this process begins when a user enters a suspected condition—such as psoriasis. The system then traces back through known symptoms and rules to determine whether the evidence supports that diagnosis. The system then searches through its knowledge base, which contains a series of predefined IF-THEN rules, to validate or refute the initial hypothesis. In the illustrated scenario, the user reports symptoms such as skin redness (kemerahan), silvery scales (sisik keperakan), and itching (gatal). The backward chaining process compares these symptoms against the diagnostic rules in the knowledge base. If the symptoms correspond to the rule set for Psoriasis, and no alternative diagnoses better fit the symptoms, then the system confirms the diagnosis as Psoriasis. It also provides an explanation for its conclusion—for example, “Psoriasis was selected because the observed symptoms match the IF-THEN rules stored in the knowledge base.”

An essential aspect of this approach is the system's ability to evaluate and eliminate other potential conditions. For instance, Atopic Dermatitis may also present with redness and itching. However, because the user's symptoms do not include vesicles (vesikel) or dry skin (kulit kering), which are typically associated with Atopic Dermatitis, the system is able to rule out this alternative.

The system's knowledge base includes diagnostic rules for 30 distinct skin conditions, such as Psoriasis, Atopic Dermatitis, Scabies, Vitiligo, and others. These conditions often have overlapping symptoms, which can make diagnosis challenging. That’s where backward chaining becomes especially

useful—it allows the system to logically trace each symptom, rule out incorrect possibilities step by step, and narrow down the diagnosis. This approach helps improve the accuracy and reliability of the results.

In summary, backward chaining provides a powerful reasoning approach for expert systems, particularly in complex fields like dermatology where accurate differential diagnosis is crucial. By beginning with a hypothesis and working backward through logical steps to confirm it, the system mirrors the way human experts think. This makes it a valuable tool for supporting clinical decision-making.

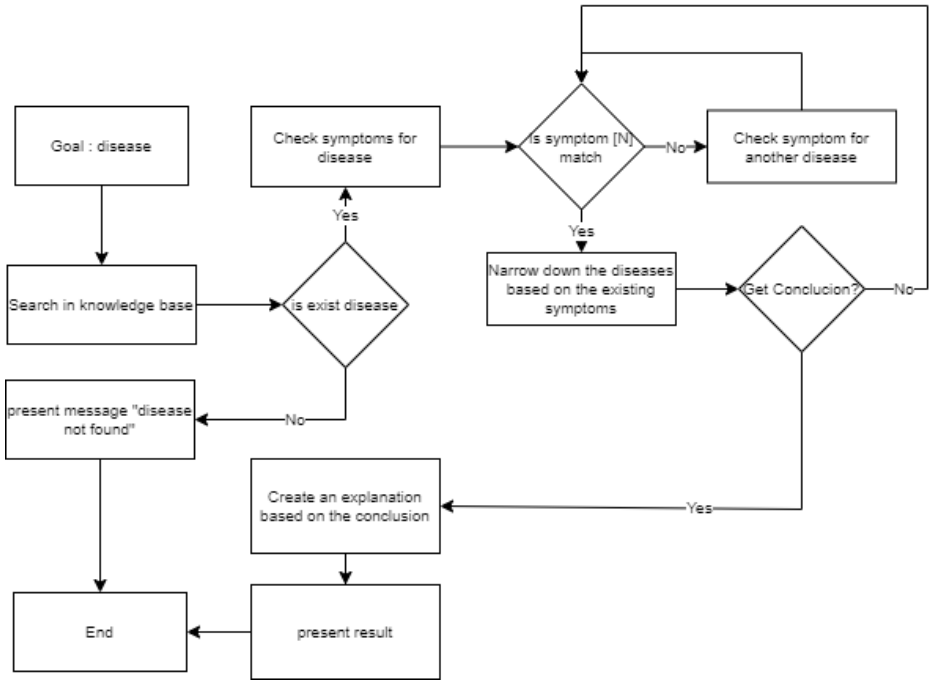

Figure 1. Backward Chaining mechanism

D. Explanation Mechanism

The explanation mechanism in this expert system model is designed to provide transparency into the diagnosis process of 30 skin diseases with similar symptoms, so that users can understand the reasoning behind the model's decisions clearly and systematically. After backward chaining inference verifies the disease hypothesis based on the user's symptoms—for example, redness, silvery scales, and itching leading to a diagnosis of Psoriasis, the explanation mechanism will expose the logical steps used, such as the corresponding IF-THEN rules in the knowledge base (IF kemerahan, sisik keperakan, gatal THEN Psoriasis), as well as why other rules such as for Atopic Dermatitis (IF gatal intens, vesikel, kulit kering THEN Atopic Dermatitis) were not selected due to symptom inconsistencies.

3. Result and Discussion

The Rule-Based Expert System Model using Backward Chaining Algorithm provides diagnostic results as decision support based on the disease specified by the user. The diagnosis is generated by matching the symptoms given by the user with the knowledge base owned by the model. If the symptoms given by the user do not match those required for the target disease, the model tries to identify alternative diseases whose symptoms are more in line with the user's input.

To assess the model's effectiveness, testing was conducted using the Test Case Validation method. This approach helps determine whether the model delivers the correct output based on specific input scenarios[25]. From the case studies, the model accurately diagnosed 9 out of 12 cases, resulting in a 75% success rate. This level of accuracy indicates how well the user's symptoms align with the IF-THEN rules in the knowledge base. For instance, the model correctly identified Psoriasis based on symptoms like redness,

silvery scales, and itching, as well as Impetigo, which was diagnosed through signs such as pustules, kuning crusts, and kemerahan.

Table 2. Testing Data

No	Goal	Symptoms	Knowledge Base(IF)	Diagnose (RESULT)	Status	Description
1.	Psoriasis	Kemerahan, sisik keperakan, gatal	IF kemerahan, sisik keperakan, gatal THEN Psoriasis	Psoriasis	Success	
2.	Dermatitis Atopik	Gatal intens, vesikel, kulit kering	IF gatal intens, vesikel, kulit kering THEN Dermatitis Atopik	Dermatitis Atopik	Success	
3.	Scabies	Gatal intens, lesi malam hari	IF gatal intens, lesi malam hari, papula THEN Scabies	Scabies	Success	
4.	Impetigo Kontak	Pustula, krusta kuning	IF pustula, krusta kuning, kemerahan THEN Impetigo	Impetigo	Success	
5.	Psoriasis	Kemerahan, gatal	IF kemerahan, sisik keperakan, gatal THEN Psoriasis	Not detected	Fail	(-) sisik keperakan
6.	Dermatitis Atopik	Gatal intens, vesikel	IF gatal intens, vesikel, kulit kering THEN Dermatitis Atopik	Not detected	Fail	(-) kulit kering
7.	Scabies	Gatal intens	IF gatal intens, lesi malam hari, papula THEN Scabies	Not detected	Fail	(-) lesi malam hari, papul
8.	Impetigo	Pustula	IF pustula, krusta kuning, kemerahan THEN Impetigo	Not detected	Fail	(-) krusta kuning, kemerahan
10.	Psoriasis	Kemerahan, sisik keperakan	IF kemerahan, sisik keperakan, gatal THEN Psoriasis	Psoriasis	Success	
10.	Dermatitis Atopik	Gatal intens, kulit kering	IF gatal intens, vesikel, kulit kering THEN Dermatitis Atopik	Dermatitis Atopik	Success	
11.	Scabies	Gatal intens, papula	IF gatal intens, lesi malam hari, papula THEN Scabies	Scabies	Succcess	
12.	Impetigo	Krusta kuning, kemerahan	IF pustula, krusta kuning, kemerahan THEN Impetigo	Impetigo	Success	

Based on the Testing Data Table above, there were 12 cases tested using the Rule-Based Expert System Model with the Backward Chaining Algorithm. From these 12 cases, 9 cases were successfully diagnosed, while 3 cases failed to be diagnosed by the model.

Total Case Tested : 12
Successful Cases : 9 (1, 2, 3, 4, 9, 10, 11, 12)
Unsuccessful Cases : 3 (5, 6, 7)
Success Rate : (9/12) × 100 = 75%

Based on the test results, it can be concluded that the model has the potential to serve as a helpful tool in supporting decision-making when identifying the type of skin disease a user may be experiencing.

4. Conclusion

Based on the development and testing of the expert system model using the backward chaining algorithm to diagnose 30 types of skin diseases with overlapping symptoms, this study demonstrates that the

approach can be a valuable tool in supporting clinical decision-making. The model achieved a 75% success rate in test case validation. Its explanation mechanism adds transparency by using clear IF-THEN logic, backed by a knowledge base built from reliable sources such as the World Health Organization (WHO), the American Academy of Dermatology (AAD), and peer-reviewed scientific literature.

Although the results demonstrate the model's effectiveness in handling specific symptoms, challenges such as partial or overlapping symptoms highlight the need for improvements, such as integrating certainty factors or adding more specific rules to enhance future accuracy. In conclusion, this model represents a promising first step in the development of expert systems in dermatology, with the potential to be expanded on a larger scale and tested in real clinical settings, while also opening opportunities for further research to address the identified limitations.

Acknowledgement

I would like to extend my sincere gratitude to all individuals and parties who provided valuable suggestions, support, and encouragement throughout the course of this research. The successful completion of this study would not have been possible without the meaningful contributions and generous assistance of those who kindly guided and motivated me at every stage of the research process.

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