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 was a computational model designed to emulate expert decision-making using a knowledge base and inference algorithms. This research developed a rule-based expert system model with a backward chaining algorithm to diagnose skin diseases based on clinical symptoms. Backward chaining, a goal-driven inference method, started with a disease hypothesis (e.g., psoriasis) and verified related symptoms (e.g., kemerahan, sisik keperakan), enabling efficient differentiation of skin diseases with overlapping symptoms, such as dermatitis, psoriasis, and scabies. The model provided advantages in handling uncertainty, produced accurate diagnoses, and supporting interactive symptom verification. Developed using a knowledge base from credible sources like WHO and AAD, the model was intended to assist in clinical decision-making. The results showed that the backward chaining algorithm effectively improved the accuracy and efficiency of diagnosing skin diseases based on patient-reported symptoms.

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1. Introduction

An expert system is a computer-based system that emulates the decision-making ability of a human expert by applying a structured knowledge base and inference mechanisms to solve domain-specific problems. Expert systems are considered appropriate when access to human experts is limited, prohibitively expensive, or when their expertise is in high demand[1]. Expert system are also applicable in scenarios requiring expert decision-making is required under adverse or complex environmental conditions. Despite its long-standing development, the expert system approach remains effective and relevant in various scientific domains [2]. One of the challenges in the medical field is skin disease, as many types share similar symptoms [3]. Several skin conditions, such as eczema (atopic dermatitis), psoriasis, and seborrheic dermatitis, have similar symptoms, despite each has different causes and treatments approach[4]. Patients often need to consult a dermatologist to receive an accurate diagnosis, as many skin diseases present with similar symptoms that can complicate proper identification of the condition[5][6]. For instance, scabies and atopic dermatitis exhibit similar symptoms, including widespread rashes and intense pruritus, particularly during nighttime [7]. Another example involves the symptoms of Herpes Simplex Virus (HSV) and Varicella Zoster Virus (VZV) infections in cancer patients, which are challenging to distinguish due to their often ambiguous, non-specific, and variable nature, resembling other conditions[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 implies that the system will pose a series of questions or seek relevant information to validate the proposed hypothesis [12].

This study aims to assist individuals in identifying their skin disease by leveraging an expert system model based on the backward chaining method, which utilizes their symptoms and corresponding hypotheses. Based on validation of test cases, the rule-based expert system model employing the Backward Chaining Algorithm developed in this study achieved an accuracy of 75%, demonstrating its potential effectiveness in accurately and efficiently diagnosing skin diseases based on clinical symptoms.

1.1 Knowledge Acquisition Mechanism

1.2 Expert system models require a knowledge base as a fundamental component [13][14]. The knowledge acquisition phase involves gathering technical documents and bibliographic sources, including reports, photographs, previous studies, and reliable references, as well as conducting regular consultations with experts[15]. Knowledge must be obtained from reliable sources, such as experts or authoritative references. In this study, the knowledge base was constructed using clinical guidelines from the World Health Organization (WHO), dermatology guidelines, and peer-reviewed scientific journals.

1.3 Knowledge Base

1.4 The primary component of an expert system model is the knowledge base, which stores domain knowledge in the form of facts and structured rules [16][17]. This component comprises a set of rules derived from reasoning processes based on previously acquired data. These rules are formulated as a series of inference statements, typically represented in IF-THEN format[18]. A Knowledge Base can be defined as a collection of information organized in a structured and interconnected manner, represented as a semantic network. This network illustrates the relationships between concepts within the knowledge base. Its structure is based on frames—data structures that store information about specific concepts[19]. Symptom data and diagnostic rules obtained through the knowledge acquisition process are organized into a knowledge base, which is then utilized by the expert system model to support backward chaining inference for diagnosis based on clinical symptoms.

1.5 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].

1.6 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 consisted of 30 skin diseases and their symptoms, many of which shared similar 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. The model then traces relevant symptoms to assess whether the hypothesis

proposed by the user aligns with the available data. 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 strategy in expert systems that begins with a specific goal and works in reverse to determine whether available facts support that goal. In the context of medical diagnostics, this technique starts when a user inputs a suspected diagnosis—such as Psoriasis. 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 share overlapping

symptoms, which makes the use of backward chaining particularly effective. It enables the system to trace each symptom logically and eliminate incorrect diagnoses systematically, ensuring a higher level of diagnostic accuracy.

In summary, backward chaining offers a robust method for reasoning in expert systems, especially in complex domains like dermatology where differential diagnosis is essential. By starting from a hypothesis and validating it through logical steps, the system mimics the diagnostic reasoning process of human experts, making it a valuable tool for clinical decision support..

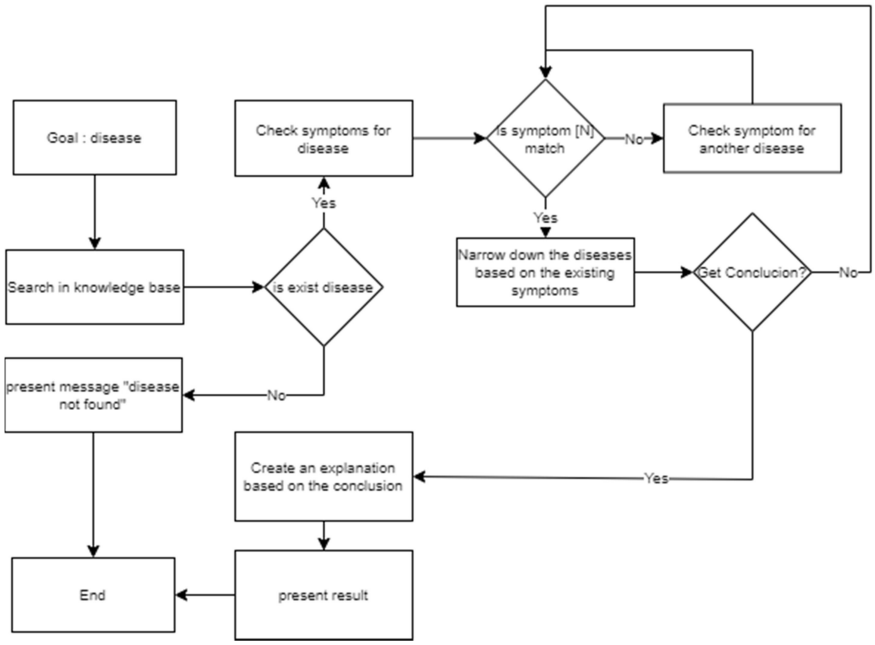

Figure 1. Backward Chaining mechanism

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 evaluate the effectiveness of the model, testing was carried out using Test Case Validation. Test Case Validation is a method used to ensure that the model produces the expected output based on specific inputs[25]. From these case studies, the model successfully diagnosed 9 cases, resulting in a success rate of 75%. This accuracy reflects the extent to which the user's symptoms match the IF-THEN rules in the knowledge base. For example, the model correctly diagnosed Psoriasis based on the presence of kemerahan,

sisik keperakan, and gatal, as well as Impetigo, which is identified through symptoms such as pustula, krusta kuning, 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 this model can be used as a tool to assist in decision-making for identifying the type of skin disease experienced by the user.

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 based on similar symptoms, this study has shown that the

approach offers a potential solution to support clinical decision-making, achieving a success rate of 75% in the test case validation. The explanation mechanism provides transparency through IF-THEN logic, using a knowledge base compiled from credible sources such as the WHO, AAD, and 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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