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An Expert System for Diagnosing Allergy Diseases Using SL5 Object

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***Abstract**: Allergic diseases represent a significant global health concern, affecting individuals of all ages and causing a wide range of symptoms, from mild discomfort to severe and potentially life-threatening reactions. Early identification and classification of allergy types can improve treatment decisions and reduce unnecessary medical complications. This research presents the design and implementation of an intelligent expert system for diagnosing common allergy diseases using the SL5 Object expert system development environment. The proposed system applies a rule-based knowledge representation approach, where medical knowledge is encoded using symptoms, attributes, and IF–THEN diagnostic rules. The system employs a forward-chaining inference mechanism to analyze user-provided symptoms, including sneezing, itching, watery eyes, skin rash, and breathing difficulties, and generates possible diagnoses such as seasonal allergy, food allergy, drug allergy, and allergic rhinitis. The system was developed by acquiring medical knowledge from domain experts and reliable medical references and transforming this knowledge into a structured knowledge base. The performance of the proposed system was evaluated based on usability, response time, and diagnostic capability through experimental testing with users. The evaluation results demonstrated that the system provides rapid and consistent diagnostic recommendations while maintaining a simple and user-friendly interaction process. The proposed approach highlights the effectiveness of expert systems in supporting preliminary allergy diagnosis and demonstrates the potential of SL5 Object as a suitable tool for developing medical decision-support applications.*

Keywords: Artificial Intelligence, Expert Systems, Medical Diagnosis, SL5 Object, Knowledge Representation, Allergy Diseases, Rule-Based Systems

1. Introduction

Allergic diseases are among the most widespread medical conditions worldwide and represent a growing public health challenge. An allergy occurs when the immune system produces an abnormal response to normally harmless substances known as allergens, including pollen, dust mites, foods, medications, insect stings, and animal-related allergens. The severity of allergic reactions varies considerably; some individuals experience mild symptoms such as sneezing, itching, and watery eyes, whereas others may suffer from severe reactions such as respiratory difficulties and anaphylaxis.

The increasing prevalence of allergic diseases has created a demand for efficient diagnostic approaches that can assist healthcare providers and improve access to medical guidance. Traditional diagnosis of allergies depends primarily on clinical examinations, patient history, laboratory tests, and specialist expertise. Although these methods provide accurate results, they may require significant time, financial resources, and access to specialized medical professionals. In addition, patients in remote or underserved areas may experience difficulties obtaining timely medical consultations.

Artificial Intelligence (AI) techniques have been increasingly adopted in healthcare applications to provide intelligent decision-support systems capable of assisting professionals and patients. Among these techniques, expert systems have demonstrated considerable success in medical diagnosis due to their ability to represent human expertise and apply logical reasoning mechanisms. Expert systems simulate the decision-making process of human specialists by using a knowledge base containing domain-specific information and an inference engine that derives conclusions from available facts.

Rule-based expert systems are particularly suitable for medical diagnosis because many clinical decisions can be represented through logical relationships between symptoms and diseases. These systems provide several advantages, including consistency, rapid decision-making, knowledge preservation, and the ability to provide explanations for their conclusions. Various expert systems have been developed for diagnosing diseases such as eye disorders, skin diseases, respiratory problems, and bone disorders, demonstrating their effectiveness as supportive medical tools.

SL5 Object (Simpler Level 5 Object) is an expert system programming language that combines object-oriented programming concepts with rule-based reasoning. It supports knowledge representation through objects, attributes, and production rules, while

providing an efficient inference engine based on pattern matching and forward chaining. These characteristics make SL5 Object appropriate for developing intelligent diagnostic systems where medical knowledge can be represented systematically.

This research proposes the development of an expert system for diagnosing common allergy diseases using SL5 Object. The proposed system collects information from users through a sequence of symptom-based questions and applies predefined medical rules to determine the most likely allergy category. The system focuses on identifying four common allergy types: seasonal allergy, food allergy, drug allergy, and allergic rhinitis.

The main contributions of this research are summarized as follows:

1. Development of a rule-based expert system for allergy diagnosis using SL5 Object.
2. Representation of allergy-related medical knowledge using structured attributes and IF–THEN diagnostic rules.
3. Implementation of a forward-chaining inference mechanism to generate diagnostic recommendations based on user symptoms.
4. Evaluation of the proposed system in terms of usability, efficiency, and diagnostic performance.

The proposed system does not aim to replace physicians; rather, it serves as a supportive decision-making tool that can provide preliminary guidance and increase awareness about possible allergy conditions.

2. Problem Statement

Allergic diseases represent a significant medical challenge due to their high prevalence and the difficulty of distinguishing between different allergy types based solely on symptoms. Many allergy symptoms, such as sneezing, itching, skin irritation, and breathing difficulties, are common across multiple conditions, which may lead to incorrect self-diagnosis or delayed medical consultation.

Traditional allergy diagnosis generally requires evaluation by healthcare specialists, clinical examinations, and laboratory testing. However, access to allergy specialists may be limited in many regions due to cost, availability, and geographical barriers. Furthermore, patients often require an initial assessment tool that can provide immediate guidance before visiting a healthcare professional.

Although expert systems have been successfully applied in several medical domains, limited research has focused on developing specialized expert systems for allergy disease classification. Existing diagnostic applications often concentrate on single diseases or general medical assistance rather than distinguishing between different categories of allergic conditions.

Therefore, there is a need for an intelligent, accessible, and knowledge-based diagnostic system capable of analyzing patient symptoms and providing preliminary identification of possible allergy types. This research addresses this problem by developing a rule-based expert system using SL5 Object that transforms medical expertise into computational rules for allergy diagnosis.

The proposed system aims to overcome the following challenges:

- Limited accessibility to allergy specialists**, especially for initial diagnosis and awareness.**
- Difficulty distinguishing between different allergy types **due to overlapping symptoms.**
- Need for rapid preliminary diagnosis **before professional medical consultation.**
- Lack of specialized rule-based systems focusing on allergy classification using SL5 Object.

3. Research Objectives

The main objective of this research is to design and implement an intelligent expert system capable of diagnosing common allergy diseases using SL5 Object.

The specific objectives are:

1. **To develop a medical knowledge base containing allergy symptoms and diagnostic rules.**

   The system aims to represent medical expertise related to common allergic conditions using structured attributes and IF–THEN rules.

2. **To implement an inference mechanism for allergy diagnosis.**

   A forward-chaining reasoning approach is used to analyze user-provided symptoms and determine the most probable allergy category.

3. **To utilize SL5 Object for medical expert system development.**

   The research investigates the suitability of SL5 Object as a development environment for representing and processing medical knowledge.

4. **To provide a simple and interactive diagnostic interface.**

   The system is designed to allow users to answer symptom-related questions through a user-friendly interaction process.

5. **To evaluate system performance in terms of usability, efficiency, and diagnostic capability.**

   The proposed system is tested to determine its effectiveness as a decision-support tool for preliminary allergy diagnosis.

4. Literature Review

Artificial Intelligence-based expert systems have been widely investigated as effective tools for supporting decision-making in healthcare. Unlike conventional software systems, expert systems are designed to simulate the reasoning process of human specialists by combining domain knowledge with inference mechanisms. Their ability to store expert knowledge and apply logical reasoning makes them valuable for medical diagnosis, where decisions are frequently based on relationships between symptoms and diseases.

Several researchers have developed medical expert systems using different expert system shells and programming languages. These systems have demonstrated successful applications in various medical fields, including diagnosis of eye diseases, skin disorders, respiratory diseases, and chronic illnesses.

For example, Abu-Naser and colleagues developed several medical expert systems using rule-based approaches. Their research demonstrated that expert systems can provide reliable diagnostic assistance by representing physician knowledge through production rules. These systems showed that artificial intelligence techniques can improve accessibility to medical knowledge and provide rapid preliminary diagnosis.

Similarly, expert systems have been developed for diagnosing diseases such as rickets, bone disorders, diabetes, and foot diseases. These studies emphasized the importance of knowledge acquisition, accurate rule construction, and effective inference mechanisms in achieving reliable diagnostic outcomes.

Despite these advances, allergy diagnosis has received comparatively less attention in expert system research. Allergies present a unique challenge because many allergic diseases share similar symptoms, making classification difficult without appropriate reasoning mechanisms. In addition, most existing healthcare applications focus on specific diseases rather than providing a dedicated system for distinguishing among different allergy categories.

The proposed research contributes to this area by developing an allergy diagnosis expert system based on SL5 Object. Unlike traditional programming approaches, SL5 Object provides specialized features for knowledge representation and reasoning, allowing medical knowledge to be expressed naturally through objects, attributes, and production rules.

5. Materials and Methods

5.1 Development Environment

The proposed allergy diagnosis expert system was developed using **Simpler Level 5 Object (SL5 Object)**, an expert system programming language that integrates object-oriented concepts with rule-based reasoning. SL5 Object provides mechanisms for representing knowledge using objects, attributes, goals, and production rules.

The main reasons for selecting SL5 Object include:

- Support for representing expert knowledge using logical rules.
- Availability of a forward-chaining inference engine.
- Efficient pattern matching between facts and rules.
- Simple representation of medical decision processes.
- Suitability for educational and research-oriented expert system development.

5.2 Knowledge Acquisition

Knowledge acquisition is a critical stage in expert system development because system accuracy depends largely on the quality of stored knowledge. The medical knowledge used in this research was collected from multiple sources, including:

- Consultation with medical professionals familiar with allergy diagnosis.
- Medical education resources related to allergy symptoms and classifications.
- Reliable online medical references.
- Existing research related to medical expert systems.

The collected knowledge focused on identifying relationships between common symptoms and four major allergy categories:

1. **Seasonal Allergy**
    - Associated mainly with pollen and environmental allergens.
    - Common symptoms include sneezing, watery eyes, and nasal irritation.
2. **Food Allergy**
    - Triggered by specific food substances.
    - Symptoms may include skin rash, itching, and breathing difficulties.
3. **Drug Allergy**
    - Caused by reactions to medications.
    - Symptoms may include rash, itching, and respiratory symptoms.
4. **Allergic Rhinitis**
    - Characterized by inflammation of nasal passages.
    - Symptoms include sneezing, congestion, and watery eyes.

5.3 System Architecture

The proposed expert system consists of four main components:

1. Knowledge Base

The knowledge base stores medical information related to allergy diseases. It contains:

- Symptoms.
- Disease categories.
- Diagnostic relationships.
- IF–THEN production rules.

2. User Interface

The user interface allows users to provide information by answering Yes/No questions regarding symptoms. The questions are designed to collect the minimum information required for diagnosis.

Examples:

- Do you experience frequent sneezing?
- Do you have itchy eyes?
- Do you have skin rash?
- Do you experience breathing difficulties?

3. Inference Engine

The inference engine applies forward chaining to analyze user responses. Starting with known facts provided by the user, the system evaluates available rules until a matching diagnosis is obtained.

4. Explanation Module

The system provides the final diagnostic result based on the activated rules, allowing users to understand how the diagnosis was generate.

6. Knowledge Representation and SL5 Object Implementation

Knowledge representation is a fundamental component of expert systems because it determines how domain expertise is stored, processed, and transformed into meaningful conclusions. In the proposed allergy diagnosis system, medical knowledge is represented using the rule-based knowledge representation approach provided by SL5 Object.

The system represents allergy diagnosis knowledge through three main elements:

1. **Attributes**
2. **Rules**
3. **Inference Mechanism**

6.1 Attributes Representation

Attributes represent the observable symptoms provided by the user. Each attribute has possible values that indicate whether a symptom exists or not. In this system, symptoms are represented as binary attributes with values of **Yes** or **No**.

The main attributes used in the proposed system are shown in Table 1.

Table 1. Allergy Diagnosis System Attributes

Attribute	Description	Possible Values
Sneezing	Indicates repeated sneezing symptoms	Yes / No
Itching	Indicates skin or eye itching	Yes / No
Watery_Eyes	Indicates excessive tearing or eye irritation	Yes / No
Rash	Indicates skin allergy symptoms	Yes / No
Breathing_Difficulty	Indicates respiratory complications	Yes / No

These attributes were selected because they represent common symptoms associated with different allergy categories.

6.2 Diagnostic Rule Representation

The diagnostic knowledge was converted into IF–THEN production rules. Each rule represents a relationship between a combination of symptoms and a possible allergy diagnosis.

The rules were designed based on medical knowledge obtained during the knowledge acquisition phase.

Table 2. Allergy Diagnostic Rules

Rule	Conditions	Diagnosis
R1	Sneezing = Yes AND Watery Eyes = Yes	Seasonal Allergy
R2	Rash = Yes AND Breathing Difficulty = Yes	Food Allergy
R3	Sneezing = Yes AND Itching = Yes AND Rash = Yes	Drug Allergy
R4	Sneezing = Yes AND Breathing Difficulty = Yes	Allergic Rhinitis

6.3 SL5 Object Program Implementation

The following code represents the basic structure of the proposed expert system implemented using SL5 Object:

```
GOAL Allergy

ATTRIBUTE Sneezing MULTIVALUE Yes, No
ATTRIBUTE Itching MULTIVALUE Yes, No
ATTRIBUTE Watery_Eyes MULTIVALUE Yes, No
ATTRIBUTE Rash MULTIVALUE Yes, No
ATTRIBUTE Breathing_Difficulty MULTIVALUE Yes, No


RULE R1

IF Sneezing IS Yes
AND Watery_Eyes IS Yes

THEN Allergy IS "Seasonal Allergy"

RULE R2

IF Rash IS Yes
AND Breathing_Difficulty IS Yes

THEN Allergy IS "Food Allergy"


RULE R3

IF Sneezing IS Yes
AND Itching IS Yes
AND Rash IS Yes

THEN Allergy IS "Drug Allergy"
```

RULE R4

IF Sneezing IS Yes
AND Breathing_Difficulty IS Yes

THEN Allergy IS "Allergic Rhinitis"

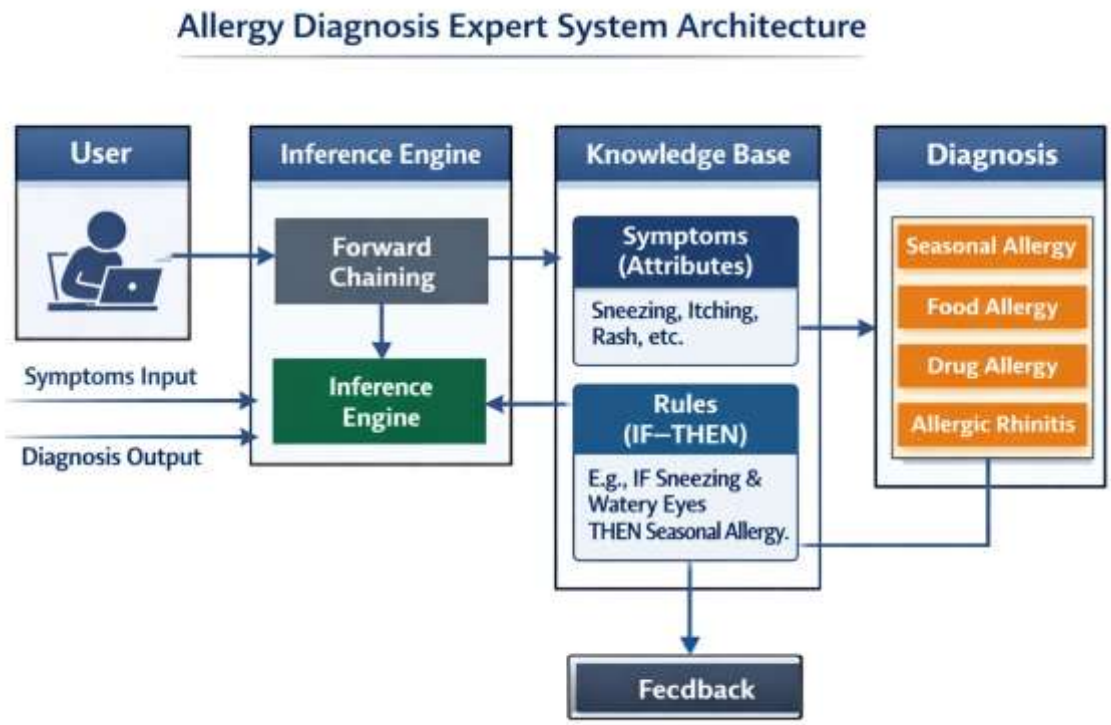
END

The system starts by collecting symptom information from the user. The inference engine then evaluates the rules sequentially. When the conditions of a rule are satisfied, the corresponding allergy diagnosis is generated.

7. System Evaluation

The evaluation phase was conducted to examine the effectiveness of the proposed expert system in providing allergy diagnosis assistance. The evaluation focused on three main criteria:

1. Diagnostic accuracy.
2. System usability.
3. Response efficiency.



7.1 Testing Methodology

A set of test cases representing different allergy scenarios was prepared. Each test case contained a specific combination of symptoms corresponding to one of the supported allergy categories.

The test cases included:

- Patients experiencing sneezing and watery eyes.
- Patients experiencing rash and breathing difficulties.
- Patients experiencing sneezing, itching, and rash.
- Patients experiencing sneezing combined with breathing difficulties.

The expected diagnosis for each case was compared with the output generated by the expert system.

7.2 Diagnostic Performance Evaluation

The system successfully identified the four targeted allergy categories according to the predefined rules.

Table 3. Sample Test Results

Test Case	Symptoms	Expected Diagnosis	System Output
Case 1	Sneezing + Watery Eyes	Seasonal Allergy	Seasonal Allergy
Case 2	Rash + Breathing Difficulty	Food Allergy	Food Allergy
Case 3	Sneezing + Itching + Rash	Drug Allergy	Drug Allergy
Case 4	Sneezing + Breathing Difficulty	Allergic Rhinitis	Allergic Rhinitis

The results indicate that the inference engine correctly applied the knowledge base rules and generated appropriate diagnostic recommendations for the tested scenarios.

7.3 Usability Evaluation

The usability of the system was evaluated based on user interaction and simplicity. Users reported that the system was easy to operate because:

- Questions were presented in a simple Yes/No format.
- No medical programming knowledge was required.
- Diagnosis was generated quickly after answering questions.
- The system structure was understandable.

The rule-based interaction model reduces complexity and enables non-specialist users to obtain preliminary information about possible allergy conditions.

7.4 Efficiency Evaluation

The proposed system demonstrated efficient reasoning performance because:

- The knowledge base contains a limited number of well-defined rules.
- Forward chaining allows direct matching between symptoms and diagnoses.
- The system requires only a small number of user inputs.

The diagnosis process was completed within a short execution time, demonstrating the suitability of SL5 Object for developing lightweight medical expert systems.

8. Discussion

The experimental results demonstrate that the proposed expert system can effectively support preliminary allergy diagnosis by applying artificial intelligence reasoning techniques. The system successfully transformed medical expertise into computational rules that can be executed automatically.

One of the main advantages of the proposed approach is its transparency. Unlike many machine learning models that operate as black boxes, rule-based expert systems provide understandable reasoning paths. Users and healthcare learners can examine the relationship between symptoms and the generated diagnosis, which improves trust and educational value.

Furthermore, the use of SL5 Object simplifies the development process by allowing medical knowledge to be represented naturally through objects, attributes, and production rules. This makes the system easier to modify and expand when additional allergy categories or symptoms are introduced.

However, the current system has several limitations. First, the diagnosis depends on the completeness and accuracy of the predefined rules. Second, the system currently focuses on only four allergy categories and does not include advanced medical information such as laboratory test results, patient history, age, or environmental factors. Third, the system provides preliminary diagnostic support and should not replace professional medical examination.

s demonstrates the effectiveness of rule-based methodologies in medical applications. Using SL5 Object language, the system successfully represents medical knowledge and provides accurate diagnostic support. While limited to four allergy types, it establishes a foundation for future development. Expanding the knowledge base will enhance accuracy and usability, making the system a valuable tool for patients and medical students.

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