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A Web Application(Asthmaontoapp) based on Ontology using SWRL Rules for the Diagnosis of Asthma

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Abstract:

Asthma is a chronic disease of the airways of the lungs caused by inflammation and narrowing of the airways. Asthma patients are sometimes misdiagnosed because of the similarity of asthma symptoms to other respiratory diseases. This leads to administering inappropriate medications, and thus the patient's condition worsens. In this search, we propose a new approach based on ontology, the aiming this method is that to develop a system that can diagnose asthma and suggest the appropriate treatment for each patient. The proposed approach consists of three steps: the knowledge base, four modules that act as mediators between the user interface and ontology, and the web application that act as an interface to the approach. Semantic Web Rule Language (SWRL) was used for asthma diagnosis. The proposed system was tested using several patients previously diagnosed with asthma. The obtained results showed that the approach could diagnose the disease and recommend treatments. It diagnosed 56 out of 59 (accuracy rate of 94.91%) and correctly recommended treatment for 20 out of 22 patients (accuracy rate of 90.9%). The approach also showed good speed in the previous two procedures, as it took 3.6 seconds to diagnose and 15.4 seconds to recommend the appropriate treatment.

Keywords: Semantic Web, Ontology, Protégé, SWRL

Introduction:

Asthma is a chronic inflammation of the airways of the lungs due to the severe sensitivity of the airways of people who suffer from it to various irritants and stimuli that cause allergies when exposed to them is a common disease. Its incidence is constantly increasing day by day all over the world. Approximately 150 million people worldwide have asthma [1]. According to international statistics, asthma is estimated at 5-10%. The incidence of asthma increases in children between four and ten years of age, especially in males, and the percentage increases after forty at age adults, especially women. This is in addition to the significant increase in the mortality rate of this disease and the high economic costs resulting from asthma (physical, psychological, and academic disabilities). The World Health

Organization has published that asthma's economic costs are equal to those of asthma About, AIDS, and tuberculosis patients combined[2].

Failure to correctly diagnose asthma affects the patient's life, leading to a lack of sleep and failure to attend a school or work due to chronic coughing and recurring attacks. It may also lead to growth retardation in children, especially if asthma is severe. Asthma may lead to death as the disease and symptoms are ignored and not detected early with the inability to recognize the symptoms and severe attacks that threaten life with the failure to control them quickly and effectively, and the failure to take the necessary precautions and medical advice[3,4].

The diagnostic error causes moderate to severe harm to patients, making it a significant medical problem and a big source of worry for both patients and doctors. Clinical negligence often results from diagnostic mistakes, which can resulted in malpractice claims. Researchers have developed many methods for minimizing diagnostic mistakes brought on by cognitive processes. This entails weighing your options, relying less on your memory, and giving you access to organized, lucid information. There is evidence that decision assistance systems minimize diagnostic mistakes

semantic web technologies was use in this study to enhance asthma diagnosis. As far as we know, Iraq does not have a reliable system for treating lung disorders. Moreover, medical systems exclusively employ database-oriented procedures rather than semantic techniques. They lack intelligence[5] and not adaptable to complex needs and processes. Semantic web technologies are utilized in medicine to handle specific problems, such as representing and considering all the data on a single patient to offer the best remedies for his ailment, especially when the data is large, as in the case of asthma. Additionally, Making decisions can be facilitated via the semantic Web, such as disease detection, in contrast to conventional technologies like the Web.

The core component of the Semantic web is an ontology that generally describes (1) (individuals: basic beings) (2) (classes: groups;) (3) properties of parameters that objects can have and share; (4) Relationships: The ways you can make them classes have some things[6].

The ontology improves problem-solving in this field. To take appropriate measures to deal with large amounts of data, the importance of ontology can be summarized as follows: [7]

- The ontological analysis clarifies the structure of knowledge.
- Knowledge can be represented singularly without the ontology that supports it.
- Ontology is a kind of recommendation that can be used in various uses and has a high probability of reboot and interoperability.
- A common vocabulary for humans.
- A common understanding of how data is organized.

In this study, we develop a prototype ontology (AsthmaOntoApp) was developed that encapsulates the body of knowledge related to asthma using an ontology, the Semantic Web rule Language (SWRL), and the query language (SPARQL). An ontology is a set of concepts, connections, and traits used to build a system for diagnosing asthma. In Web Ontology Language (OWL), an ontology language used to create ontologies or knowledge bases, AsthmaOntoApp was represented.

The semantic Web's basic language, the SWRL rule, was created. It allows users to create the first-order reasoning rules necessary for reasoning about particular OWL persons. Valid links between ontology categories for an asthma diagnosis are used to construct SWRL rules. Existing ontology knowledge rules and patient data are utilized to infer new knowledge using the rules. Putting all the rules into ontology terms (classes, properties, individuals). Ontology rules and SWRL rules have been employed extensively in biomedicine. The most relevant works, except for a few, concentrated on developing broad ontologies for various disorders. Several prevalent illnesses include general cancer and coronary artery disease. As far as we know, no one uses the semantic Web to serve Certain diseases, such as asthma, in Iraq.

This research intends to build an ontology-based system that will aid in diagnosing asthma conditions for patients and offering suggested remedies. Before collecting patient data for usage, we reviewed the works relevant to current research related to our research in the same field and problem. Then, we developed a prototype of the suggested system using people from our ontology of asthma.

it consists of the following main units:

1 Querying Module
2 Reasoning Module
3 Diagnosing Module
4 Recommending Treatment Module

Diagnostics are done by checking user input for various questions related to symptoms and risk factors for asthma. All relevant diagnostic bases and OWL knowledge are extracted from the field of Ontology. Pellet Reasoner uses patient data and SWRL rules to derive and present inferences, Recommend diagnosis, and recommend appropriate treatments for the condition.

The current paper uses ontology as a computational tool to solve clinical medical issues. Medical ontology is utilized to address issues in the biomedical and medical areas, including the detection and treatment of diseases [9].

1. Theoretical Background

This part offers the theoretical context and thought processes required to understand the strategies used in the following section.

1-1 Semantic web

Tim Berners-Lee is credited for coining the term "semantic web" to describe a network of data that computers can analyze, one of the recent IT innovations [10]. Making the Web a truly collaborative platform for people to share information and services, as well as making it simpler to combine data from various sources and formats, were the early goals of Tim Berners-for Lee's Semantic Web. Creating a Web that machines could understand and process was the second aspect of his idea. Tim Berners-Le envisions new web pages that computers can comprehend, integrate, and analyze to enable humans and computers to collaborate like humans cooperate [11]. Existing web pages can currently be read and understood by humans.

1-2 Ontology

Ontology is a formal identification of concepts within a field and their relationships.[12]. It is used to represent the knowledge domain. Knowledge contains a set of concepts. Concepts and individuals belong to these concepts and are a set of relationships. (Relationships between concepts) and between concepts and individuals (13). Ontology plays a major role in exchanging information in various fields [14].

1-3 Web Ontology Language (OWL)

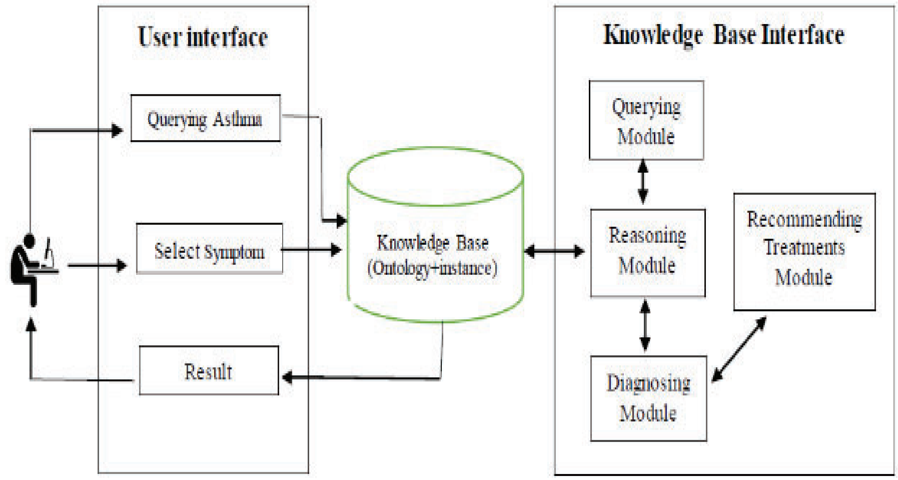
It's a semantic web language made to express sophisticated knowledge. Ontology on the Web can be defined and created using this language. OWL Ontology provides detailed descriptions of an entity's classes, properties, and individuals and the potential for including those entities' properties [15]. The characteristics of web resources can be described using OWL Ontology [16]. For computer programs to utilize the knowledge expressed in OWL, it is also a computational language founded on logic [17].

1-4 Protégé Tool

We have opted to utilize the Protégé tool for building ontologies as part of our efforts to enhance our comprehension of asthma. This tool is supported by Stanford University and is a framework for creating intelligent systems that are open-source and free for editing ontology documents [18]. We have chosen Protégé from several available ontology-building technologies to design and construct our ontologies.**2- The structure of the proposed approach**

The structure of the proposed approach, As shown in figure(1), consists of the following units:

1. **Knowledge Base**: It is an ontology comprising two components. The suggested ontology is presented in section one. The cases added to the ontology to create a rich knowledge base represent the second par.
2. **Querying Module**: By using this module, we can respond to particular inquiries regarding asthma that are challenging to address by directly examining ontology. We may extract, filter, compute, and summarize knowledge from the suggested ontology using SPARQL queries.
3. **Diagnosing Module**: After receiving the user's defined symptoms through the user interface, this module determines whether the patient has asthma by sending the specified diagnostic rules to the inference module to apply and run on ontology. It then sends the results to the user by displaying them on the web page.
4. **Recommending Treatment Module**: it offers suggested remedies via a knowledge base that includes options for each instance of the disease and following the patient's state.
5. **Reasoning Module**: takes many rules from the diagnosis and therapy recommendation modules, applies them to the ontology, and then runs the Reasoner Pellet on the ontology to discover new facts and relationships.
6. **User interface**: The purpose of the user interface is to send user inputs, such as symptoms, to the knowledge base interface, then receive the results from the knowledge base interface, such as search results or disease diagnosis, and then arrange, format, and display them appropriately on a web page so that they are ready for use by the user.



Figure(1):show the proposed system structure

The main tasks of the approach

1- Asthma Diagnosis
2- Treatment recommendation.
3- General protocol of treatment
4- Asthma control test
5- Asthma type test
6- Asthma Severity Classification Test
7- General information about asthma

To perform these tasks as above, the following steps are followed:

1 Data collection
2 Building an ontology
3 Create semantic rules
4 inference
5 Query
6 Design of AsthmaOntoApp.

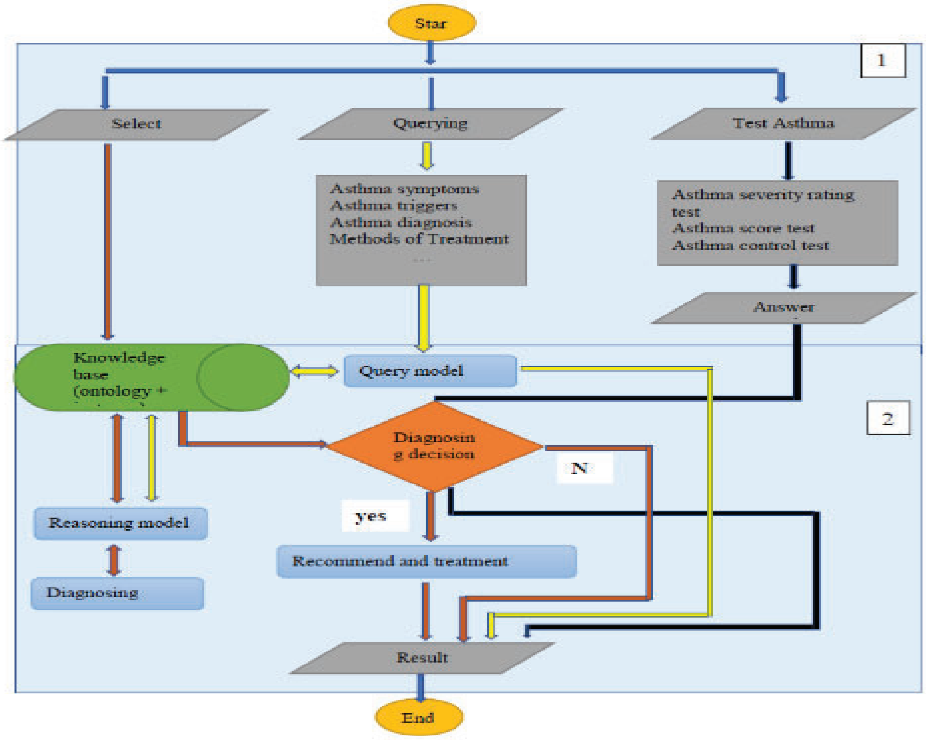
2-1 work phases of the proposed approach

The proposed approach's inputs are symptoms, asthma inquiries, and tests. The output is the diagnosis of the condition, the recommendation of treatments if the patient has asthma, the results of the tests, and finally, the results of the required queries that the user has submitted. The flowchart in Figure (2) shows the stages of the proposed system. Based on the flow chart, the work stages of each input to the system will be explained, as they include the inputs of the system the following-:

1- Selection of symptoms

2- Asthma tests

3- Query



Figure(2): show the stages of the proposed system

2-1-1 Symptoms selection

Through the system's main interface, several questions directed to the user related to symptoms and other questions appear specific to the patient for diagnosis. After the user answers the questions, the answers are sent to the ontology knowledge base. The inference engine is run to infer the diagnosis through the diagnostic module that contains SWRL rules. Then the results are sent to the user interface.

2-1-2 Asthma tests

The main interface of the app includes three asthma tests. After the user clicks on one of them, a set of questions appears to him. When the user completes the answer to all the questions, they are processed by calculating the total points for each question. Based on the sum, the result is given or specified according to the question answered.

2-1-3 Query

The user can inquire about everything related to asthma, including symptoms, diagnostic methods, triggers, and other information. When the user clicks on any option, he moves to the query unit, which sends Sparkl instructions to the inference unit to execute and run the query in the knowledge base (ontology). After that, the knowledge base sends the results. to the user interface

2-2 Patient data collection

An electronic questionnaire was conducted to collect information from many patients from inside and outside Iraq. Then the data was arranged and prepared for inclusion in the proposed ontology as a knowledge base. Through this, a rich knowledge base and ontology were formed to build the proposed approach.

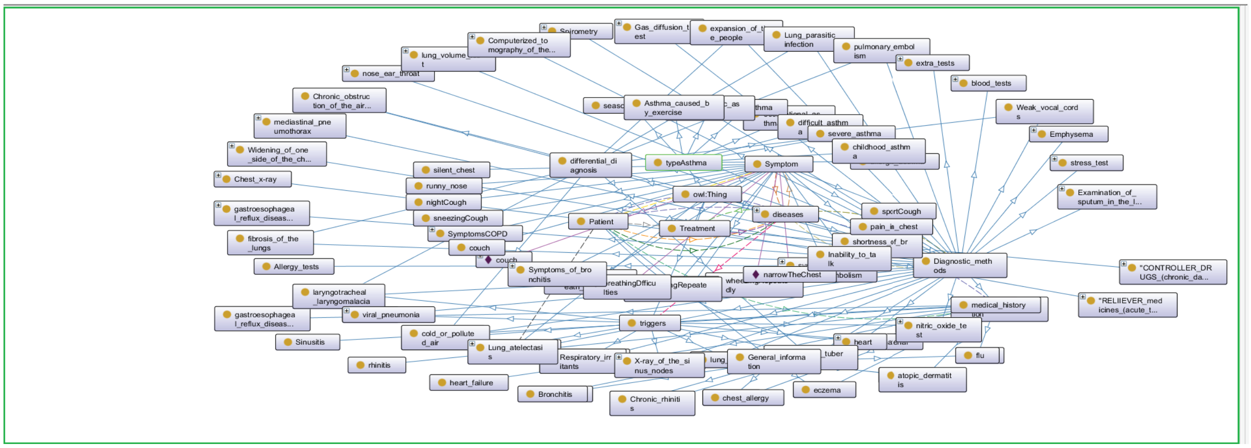
2-3 The construction of ontology

A set of research articles and other documents pertinent to the medical were used to develop ontology contents for the topic of asthma. We used the terminology provided in the Asthma Diagnosis and Treatment Workbook [19] as a starting point when creating an ontology of asthma. We also held many meetings and interviews with pulmonologists, asking them to describe their steps to diagnose and treat patients.

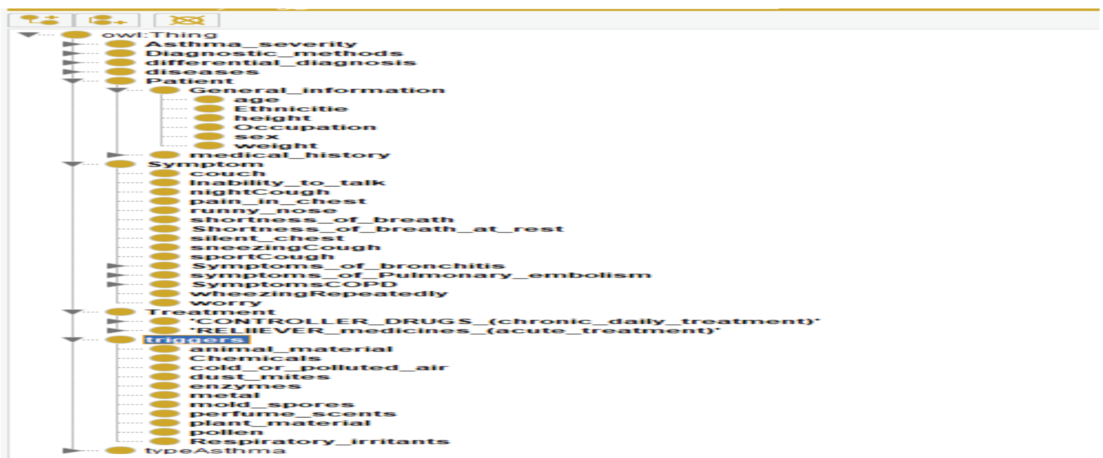
A model of knowledge from the field of asthma is known as an asthma ontology. It includes pertinent terminology for diagnosis, patient information (personal details, symptoms, risk factors, and results of clinical tests), and treatment. Protégé is used to implement the ontology in OWL format. We used a top-down approach To build an ontology, where abstract concepts are defined first and then specialized in more specific concepts. An ontology for asthma was built by following the steps previously specified by the development guide to ontology [20], which starts from the step of defining the field and scope of the ontology and a set of other steps and ends The evaluation step (testing) of the ontology is as follows

1. Define the domain and range of the ontology.
2. Consider reusing an existing ontology.
3. Count important terms in the ontology.
4. Define classes and the hierarchy of classes.
5. Determine the properties of classes (Classes - Slots).
6. Determine the faces of the slots.
7. Create instances.
8. Existential assessment.

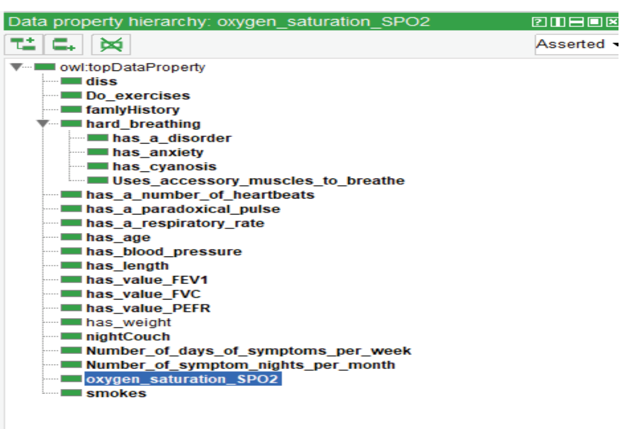
We have developed a specific ontology of asthma with several components, such as classes, relationships, individuals, and axioms. Figure (3) shows part of the main classes schematically in a tool protégé. Figure(4) shows the hierarchy of ontology categories. Figure(5) shows the object properties, and Figure(6) shows the data properties.

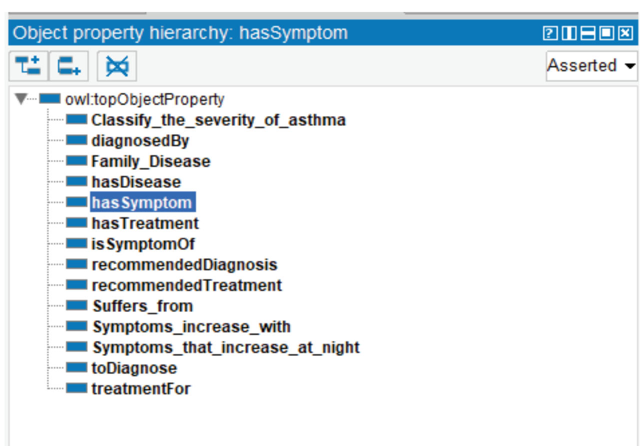


Figure(3):show the main classes



Figure(4): present process the hierarchy of ontology categories





Figure(5): show the object properties

Figure(6): show the data properties

2-4 Create semantic rules

A set of rules has been defined to obtain specific information from the knowledge base for diagnosing asthmatic patients, obtaining recommendations for appropriate treatments, and a general treatment protocol for each new patient.

We chose JENA's base language among different semantic grammar languages, such as SWRL, to generate the desired grammar that we used in our approach. A set of SWRL rules were established to infer the diagnosis from the knowledge base. The SWRL rules were developed within the concept of "diagnosing asthma" and expressing all the rules in terms of ontology concepts, classes, properties, and individuals), where these rules are based on the concepts of the field of ontology that allows it to be expressed in an SWRL Many rules have been written for diagnosis, and below are some of the rules for diagnosis:

```
Patient(?p) ^ hasSymptom(?p , couch) ^ hasSymptom(?p , pain_in_chest) ^
hasSymptom(?p,Shortness_of_breath) ^ smokes(?p,true) ^
Symptoms_increase_with (?p , pollen) ^ famlyHistory(?p , true) ^ Suffers_from
(?p , Chronic_rhinitis) ^ Symptoms_that_increase_at_night( ?p , couch) ->
recommendedDiagnosis (?p , asthma).
```

```
patient(?p) ^ hasSymptom(?p , couch) ^ hasSymptom(?p , shortness_of_breath) ^
hasSymptom(?p, wheezingRepeatedly) ^ hasSymptom(?p ,runny_nose) ^
hasSymptom(?p, worry) ^ nightCouch ( ?p , true) ^ Methacholine assay ( ?p ,
true)
Symptoms_increase_with (?p , animal_material) ^ Symptoms_increase_with (?p
, Chemicals) ^ Symptoms_increase_with (?p , cold_or_polluted_air) ^
Symptoms_increase_with (?p , enzymes) ^ Suffers_from (?p , chest_allergy) ^
Symptoms_that_increase_at_night( ?p , shortness_of_breath) ->
recommendedDiagnosis (?p , asthma)
```

2-5 inference engine

The search engine for new relationships from existing relationships and effects contradictions and check them. It can identify the different types of ontological relationships, such as transitive, homonymous, inverse, and functional genitives.

2-6 Query

Query allows execution of query statements written in SPARQL Query or DL Query. It enables us to retrieve the reference information and retrieve the derived information. We can answer very specific questions about a viewing disease that are difficult to answer by looking at existence directly. It means querying all parts of the system to retrieve the required information as needed, such as asthma symptoms and asthma triggers

2-7 Design application of AsthmaOntoApp

AsthmaOntoApp is designed so the user can easily interact with it and get the appropriate diagnostic results for a particular patient according to the patient's symptoms and information. AsthmaOntoApp is developed using HTML + python for the front end using the flask framework to provide different interfaces to the system. Figure (7) shows the main interface of the application. Figure (8) shows the diagnostic result interface of the application.

Figure(7): shows the main interface of the application

Figure(8): show the diagnostic result interface of the application

3- Discussion and Future Work

In this study, we built an SWRL rule set and a strategy based on ontologies for the diagnosis of asthma. And delivering the main treatment regimen and treatment recommendations initially to assist patients with diagnosing and recommending treatments for their asthma, created an existential knowledge base specifically for asthma. The existential knowledge base includes pertinent terms for diagnosis, patient information (personal details, symptoms, and triggers), and treatment. Afterward, data was gathered regarding asthma Patients and using a questionnaire to enrich the ontology. We determined a set of semantic rules to accomplish our objectives, where SWRL rules were established from the appropriate relationships between the ontology concepts for diagnosing asthma and providing treatment recommendations and the general protocol for treatment. We then created a prototype of various units, including the Query module, Inference module, Diagnostics module Recommend treatments module. The diagnosis procedure involves examining the user's responses to various questions on asthma symptoms and risk factors. Ontology is the source of all the diagnostic guidelines and related information. The inference engine makes inferences based on patient data and then recommends a diagnosis and course of therapy. Second, the method's effectiveness in saving time was assessed by measuring the speed of processes. The method's accuracy in identifying asthma was 94.91%. It has produced good results, with a therapy suggestion accuracy rate of 90.9%. The approach had an average efficiency of 3.6 seconds during the diagnosis phase and 15.4 seconds throughout the recommendation process. The key contributions of this thesis are the ontology and pertinent information base that can help diagnose asthma, offer suggested treatments and offer a general treatment plan.

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