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Diagnosis Prediction of Thyroid Disease Using Knowledge-based Expert System

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Abstract
Expertise systems represent one of the most important sciences of artificial intelligence that offer systems developed to take the place of experts, especially in a specific field, where these systems can be consulted to perform a specific task in the specialized field of this system. Expert systems play an effective role in the scope of medical diagnosis in terms of identifying sites of weakness and causes of deficiencies in cases that are difficult to diagnose based on the symptoms observed from the diseases. The expert system is used as an intelligent medical diagnostic based on patient data. This study aims to develop an expert system to diagnosis thyroid diseases using knowledge representation of production rules. The knowledge base and the inference mechanism has discovered and included in the system, it depends on the forward inference method in building the diagnostic system. Thyroid disease is considered one of the most dangerous and widespread diseases due to its severity as a fatal disease that make it difficult to diagnose types of thyroid diseases. This study presents the medical diagnostic system for thyroid diseases of the five most common types, Hypothyroidism, Hyperthyroidism, Hashimoto, Graves and Nodules thyroid. The system was tested and evaluated and its performance by presented to experts and specialists in medicine field with 85% diagnostic accuracy on 92 cases. It can be utilized to diagnose thyroid diseases with faster, accurately and high efficiency than the traditional diagnosis.
Keywords : *Expert system, Knowledge, Thyroid disease, Medical diagnostic.*

الملخص
تمثل أنظمة الخبرة أحد أهم أنظمة الذكاء الاصطناعي تقدم أنظمة مطورة لتحل محل الخبراء في مجال معين، يمكن استشارة هذه الأنظمة لأداء مهمة محددة في المجال الذي يتخصص فيه هذا النظام. الأنظمة الخبيرة تلعب دورًا مهم في التشخيص الطبي من حيث تحديد مواقع الضعف وأسباب القصور في الحالات التي يصعب تشخيصها بناءً على الأعراض التي يتم ملاحظتها من الأمراض. النظام الخبير يستخدم برنامج تشخيص طبي ذكي يعتمد على بيانات المرضى. الدراسة تهدف إلى تطوير نظام خبير لتشخيص أمراض الغدة الدرقية باستخدام النظم الخبرة المعتمدة على المعرفة. تم اكتشاف قاعدة المعرفة وآلية الاستدلال وإدراجها في النظام، وهي تعتمد على طريقة الاستدلال الأمامي في بناء نظام التشخيص. يعتبر مرض الغدة الدرقية من أخطر الأمراض وانتشارها بسبب شدته كمرض قاتل ومميت يجعل من الصعب تشخيص أنواع أمراض الغدة الدرقية. تعرض هذه الدراسة نظام التشخيص الطبي لأمراض الغدة الدرقية للأنواع الخمسة الأكثر شيوعًا قصور الغدة الدرقية، فرط نشاط الغدة الدرقية، هاشيموتو، جريفز وعقيدات الغدة الدرقية. تم اختبار النظام وتقييمه وعرض أدائه على الخبراء والمتخصصين في مجال الطب بدقة تشخيصية 85٪ على 92 حالة. يمكن استخدامه لتشخيص أمراض الغدة الدرقية بشكل أسرع ودقيق وكفاءة عالية من التشخيص التقليدي.

الكلمات المفتاحية: الأنظمة الخبيرة، المعرفة، أمراض الغدة الدرقية، التشخيص الطبي.

1. Introduction

Artificial intelligence (AI) is a computer science discipline that focuses on developing machines that simulate human work. 1940 AD, when computers and robots began to be programmed to be able to perform some complex tasks such as classification and prediction, diagnosis, segmentation, optimizing solutions and recognizing lines and sounds electronically and others [1, 2]. Artificial intelligence, on the other hand, is considered an expert in many areas, including disease diagnosis, classification, and disease prediction. This study is related to the use of Expert Systems (ES), a computer program that uses AI technology, to simulate the judgment and behavior of a person or organization that has technical knowledge and experience in a particular field. It has been supplied. ES aims largely at designing software that tries to simulate experts, to reach the way of his behavior, behavior and thinking to make decisions and solve complex problems that require human expertise to solve [3].

ESs are the result of nearly thirty years of hard work by AI scientists to design computer programs can somehow solve problems that are intelligent behavior if done by humans. ES contain a huge amount of information owned by an expert in a field of knowledge, and some of these programs have proven their effectiveness to confirm the possibility of replacing them with the human expert himself [4]. There are many applications of expert systems that are important and most effective in the consulting or decision-making. The decision-making process is a logical process carried out by the decision-maker after taking into account many matters of different degrees of importance, balancing them, and then formulating the final decision that achieves the best possible specifications according to the objective circumstances.

These systems have developed during the period 1986-2021, and despite the existence of differences between them, they share the foundations of their work and their acceptance of experience in the form of rules. Software means have been developed in expert systems to be suitable for such applications, and thus these systems entered the administrative, economic, engineering, agricultural, medical and other fields [18].

Expert systems in the field of medicine are a computer program that uses AI technology, to support medical workers while performing certain tasks that depend on deliberating known data. In the data indicate significant changes in the patient's condition.

Early and accurate diagnosis of many diseases is critical to their treatment. Today, classification models based on fuzzy intelligent systems assist in the conditions of uncertainty in medicine, as well as the classification of diseases. The main objective of this study is to diagnose the most common thyroid disorders, using an expert system based on production rules.

2. Literature Review

There are many well-known expert systems that have met with success in their field of specialization applications in various fields, including the medical, geological and other fields, and among these systems that represent the first successful systems, the MYCIN expert system was developed in 1976 at Stanford University in the United States of America, and is one of the oldest The expert systems that have been successfully formulated provide advice for the diagnosis and treatment of diseases resulting from blood contamination, inflammation and infection. The expert system MYCIN depends on the method of dialogue with the doctor who uses it by asking him questions to gather facts and information about the patient whose condition is to be diagnosed, to reach a conclusion about the diagnosis of the disease and to determine the necessary treatment [5].

The expert system is considered one of the widest expert systems in the field of medicine, and it contains wide capabilities and many functions, and its results can be given by more than one formula, including the probabilistic formula. The Leonardo expert system has some scientific limitations, although it has multiple capabilities, the system has been used VP-EXPERT system in a number of important applications that have an effective role in our scientific and practical life. Also, DENDRAL is an expert system for determining the partial composition of soils whose mass spectral data are not known (Feigenbaum et al 1971), and uses Forward Chaining. Most systems of backward inference experience are used for diagnostic purposes. For example, the MYCIN medical expert system used to diagnose infectious blood diseases uses Backward Chaining [18].

Based on [20] this expert system, CADUCEUS, has been developed that can give the correct diagnosis of examination cases in internal medicine by having rules of interrelationship between diseases and symptoms in the field of internal medicine. In 1975 he developed the INTERNIST system capable of diagnosing more than 500 clinical symptoms.

In another study, the researchers [6] provided an electronic system that relieves medical staff and provides quick solutions to some first aid cases, as the system provides multiple simple medical services through the internet of the ambulance center, which enables its presentation to obtain knowledge without the need to visit the center itself directly. To implement this study, the artificial intelligence system was used, which is the expert system, and the system was developed permanently in line with the objectives of the study, in addition to that, medical progress in the field of first aid is constantly evolving and needs a system that is capable of being updated.

Building on [7] this rules-based system was developed to assist people in preventing and early detection of breast cancer. As it is known, this disease has no cure or treatment so far. SL5 object language was used in the design of this rules-based system.

The researchers also proposed a specialized system created to help dermatologists develop an expert system for diagnosing skin diseases using the CLIPS C language integrated production system to help the user diagnose the following skin diseases (psoriasis, eczema, ichthyosis, acne, meningitis, scarlet fever, warts, insect bites and stings), an overview of skin diseases was presented, the causes of diseases were identified and the disease treated whenever possible [8]. In [9] presented an expert system design that provides the patient with a background for the appropriate diagnosis of some eye diseases. CLIPS used as a tool for expert system development. An initial evaluation of the expert system was performed and the result was positive.

In study of the object language SL5 was used in the design of this rule-based system, and the researchers presented the development of an expert system capable of recognizing the disease that affects the kidneys by identifying the symptoms that appear from the list of symptoms that appear to the doctor to avoid the user typing the symptoms incorrectly. With his experience, he achieved satisfactory results [10]. According to [11] presented a study to apply an expert system using SL5 to diagnose the patient's condition and provide the appropriate solution. The system aims to help clinicians detect hepatitis diseases. This program has been evaluated and tested by a group of doctors and patients with liver problems and they were satisfied with its performance. The proposed expert system is very useful for clinicians to diagnose and treat liver disease whenever possible.

In the field of diagnosing thyroid diseases in particular, researchers have presented expert systems that have been successful in the field of medical diagnosis. In the study [12] proposed an expert system for diagnosing thyroid disorders, using an ambiguous rule-based expert system. Where the data collection contains 305 subjects in three categories which are normal, subclinical hypothyroidism and hypothyroidism. The system performance was compared with a polynomial logistic regression model in terms of accuracy and area under the ROC curve (AUC) as well as sensitivity and specificity. The results showed that the system based on the designed rules works well in predicting thyroid disorder with an accuracy of 97%. Also, the fuzzy classifier has better performance than the logistic regression model, especially for the subclinical hypothyroidism category.

In another study [13] the authors presented an approach based on mapping a multi-layered fuzzy inference system (ML-MFIS) to analyze thyroid disease (TD). Suggested expert system (TDI-EFL Expert) based on symptoms and tests used to diagnose thyroid disease. The system is based on thyroid disease detection supported by the Fuzzy Logic Expert system in two layers to identify hyper or hypothyroidism. The system presents an analysis of accurate results using the proposed definition of thyroid disease with the enablement of fuzzy logic with the help of

medical specialists, collected from Sheikh Zayed Hospital, Lahore, Pakistan. The TDI-EFL expert system has achieved 85.33% accuracy in diagnosing thyroid disease.

Based on [14] the researchers presented an expert system for obtaining a proper diagnosis of thyroid diseases. The cause of the diseases has been identified and the disease treated whenever possible. The SL5 Object Expert System language was used to design and implement the proposed system. The expert system for the diagnosis of thyroid diseases was evaluated by medical students and clinicians as they were satisfied and accepted by the quality of its performance. Conclusions: The expert system is easy for podiatrists, patients and people with experience in detecting and diagnosing symptoms that may experience this disease.

According to [15] the expert system is designed to diagnose hair loss diseases such as seborrhea, lichen planus, ringworm, alopecia areata, thyroid diseases and male pattern baldness, the cause of the diseases is identified and the disease treated whenever possible. The Clips Expert System language was used to design and implement the proposed expert system. The proposed system was evaluated by medical students and they were satisfied with its performance. The system has proven to be very beneficial for a hair loss doctor, patients with hair loss problems and a newly graduated doctor.

In another study [16] an expert system was developed capable of diagnosing hyperthyroid using the certainty factor method (CF), and the cause, symptoms and treatment of the disease were identified whenever possible. The system has helped the user to determine the disease diagnosis in confirm the diagnosis to provide advice of and disease treatment. Test results show that this proposed expert system can diagnose hyperthyroidism according to the answers provided by the user with 100% accuracy.

Preliminary Study on Thyroid Diseases

The thyroid gland is an endocrine gland located at the bottom of the neck. It controls blood pressure, heart rate, body temperature, weight, and other vital functions. The thyroid gland secretes three thyroxine hormones, and it has a major role in regulating: metabolism, digestion, heartbeat, muscle functions, and maintaining bone health, triiodothyronine, The thyroid gland has a major role in regulating metabolism, digestion, heartbeat, muscle control, and brain control, maintaining of bone health, calcitonin, and regulating calcium level in the body.

The thyroid gland may be affected by thyroid diseases known since ancient times. Its symptoms were described for many reasons by famous doctors, including Hippocrates, who spoke about it without giving an explanation of its anatomical nature, and the causative factors that were not revealed until recently in 1947. Scientists were able to differentiate between the types of diseases that cause diseases. Thyroid gland, and in some cases the thyroid gland may increase in size more than normal, which is known as goiter, and the enlargement is usually painful, and the most common cause of swelling is a lack of iodine in food, and often goiter

occurs as a result of To a lack or excess of thyroid hormones secretion, or the growth of nodes on the gland itself [17].

Scientists have been able to discover hypothyroidism and hyperthyroidism. When your thyroid gland doesn't produce enough of some important hormones, hypothyroidism can cause a number of health problems, such as obesity, joint pain, infertility and heart disease. Hyperthyroidism is when the thyroid gland produces a large amount of the hormone thyroxine. An overactive thyroid can cause your metabolism to increase, resulting in unintended weight loss and a fast and irregular heartbeat.

1988 Houghton and his colleagues at the Chiron Foundation in the US presented the factors responsible for thyroid disease and called these factors Hashimoto's disease. Grave's Disease, and scientists have classified thyroid diseases into types, namely hypothyroidism, hyperthyroidism, and Hashimoto's disease. This disease affects humans when the immune system mistakenly attacks the thyroid gland, which weakens its ability to produce and secrete hormones. Various, Grave's Disease is the most common condition of hyperthyroidism, and a person develops when the immune system attacks this gland, results in an increase in the secretion of its hormones responsible for regulating metabolism, and thyroid nodules, which are solid or fluid-laden nodes that arise in your thyroid, a small gland located in the lower part of your neck, just above the breastbone, has different symptoms, diagnosis, and treatment [18].

From this principle, the study came to develop an expert system aimed at diagnosing the five types of thyroid diseases, which are hypothyroidism (Hypo), hyperthyroidism (Hyper), Hashimoto's disease (Hash), Grave's disease (Grave) and Thyroid nodules (Node). The study is able to diagnose the disease according to the patient's data and determine the percentage of each of the five thyroid diseases with the ability to store patient data based on the patient's condition as having a type of diseases and retrieve the data to help facilitate the work of experts in medicine. The study conducted at General Murzuq Hospital and Village Traghen Hospital.
The study is concerned with assisting experts and the work team in various health institutions in maintaining and preserving knowledge from extinction. This unique valuable knowledge that is available to experts that distinguishes him in his specialization. The study can solve problems, which saves time, money and effort, and this is what makes us need a huge database. The study is important to provide a computer system for health institutions to store data, which works to save patient data and avoid its loss. As well as increasing the experts in the field that makes the expert system.

3. Materials and Methods

The proposed expert system diagnoses five thyroid conditions by asking yes or no questions. The proposed expert system will ask the user to choose the correct answer on each screen. At the end of the session, the proposed expert system presents the diagnosis and recommendation

of the disease to the user. Figure 2 shows a sample of the dialogue between the expert system and the user. Figure 3 shows how users obtain the diagnosis and recommendation.

4. Experimental

The experiments of the system are to develop an expert system in the field of medicine for diagnosing thyroid diseases, using the Visual Basic programming language to program the system, and Microsoft Access database management system to design database tables to save the knowledge gained from experts related to the thyroid disease diagnosis system.

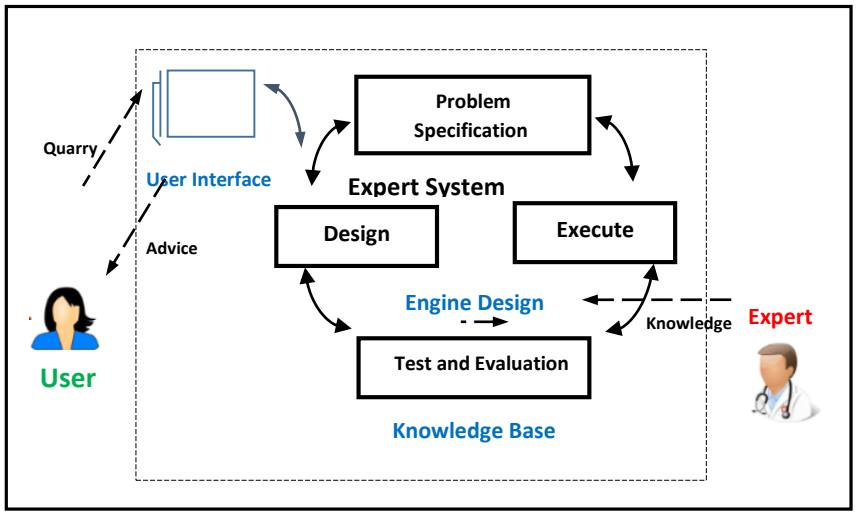

Figure 1. The steps involved in building the expert system

The expert system was developed by following four basic stages known as the Expert Systems Development Lifecycle, which is divided into three main stages in which each stage depends on the stage that precedes it. Implementation of the prepared designs to ensure the effectiveness of the system [19]. These stages are illustrated in Figure 1.

The expert systems development lifecycle stages are well-defined stages of specification and system development. According to [19] the process of building any expert system goes through stages called the life cycle or software processes as follows:

- Knowledge Base

Contains high-quality knowledge and industry-specific to demonstrate intelligence. The achievement of expert system depends to a large field on the earlier experience and the crowd of actual precise and accurate information about the commission field known as knowledge.

- Inference Engine

The utilizing of effective rules and procedures by the inference engine is important in arising a right and perfect solution.

In the occasion of a rule-based expert system, it relays the rules iteratively to evidences achieved from the preceding rule application. Then it enhances new evidence to the knowledge base if essential. Last rule conflict decides when multiple rules execute to a certain case.

- User Interface

User Interface provides interface between the users of the expert system. It is natural language processing, it is utilized by the employer experienced in the extent of the task. An expert system user does not necessarily need to be an AI expert.

a. Knowledge Acquisition

The key sources of expert system knowledge is the skillful and specialist in thyroid disease methods. The learned knowledge is converted to the knowledge base. Presently in the expert system has five conditions causing thyroid disorders, each type contains a number of symptoms, an effort to build a system to change the doctor in medical field. The method uses human knowledge extracted from experts to explain problems that involve human skill, and this study is used to extract scarce knowledge resources to get better and corresponding results.

The basic model of knowledge engineering depicts the work of a team in which the knowledge engineer mediates between the expert and the knowledge base to extract knowledge from the expert, implement it with the expert, and represent it in the knowledge base. There are many ways in which a knowledge engineer can extract knowledge from an expert. A first, personal encounter, which is the most common form of obtaining knowledge, is face-to-face analysis, which is an explicit method. The method used as a means of obtaining knowledge by conducting interviews with the doctors working in Murzuq Hospital and Traghen Hospital, who are Dr. Magdy Mahmoud, Internal Medicine Specialist, PhD from Ain Shams University in 1983. Traghen Hospital, Dr. Moataz Al-Amin, an internal medicine specialist, obtained a doctorate from Al-Fateh University in 1992, Murzuq Hospital. Notes and information are taken and recorded, so that the knowledge of the system becomes in the form of symptoms for each thyroid disease (Hypo, Hyper, Hash, Grave and Node). Secondly, formulas and documents in which all information (knowledge) is collected through documents, books and scientific journals to obtain knowledge of the system related to the five types of thyroid disease, the symptoms of each disease, how to diagnose, treat and how to prevent them. Finally, the observations are possible to detect by the expert during his field work. . In many cases, this is the most straightforward and straightforward way of obtaining information as this method has been used to observe doctors how the diagnosis is made. And then take advantage of this method to develop a design for the system that is closer to the expert.

b. Knowledge Representation

After completing the collection of data and information and obtaining knowledge related to the system, then representing the knowledge gained from the experts

In this field, in the form of facts, rules, and procedures extracted from the specialized doctor that enable us to make the decision to diagnose thyroid disease, and the knowledge was represented in the form of questions in fact, which are symptoms of thyroid disease of its five types. The acquired knowledge is considered symptoms of each disease and then represented in the form of questions and stored in the database called the knowledge base which descripts the Inference engine. The knowledge presents 47 questions were extracted from many different experts and analyzed on each of the five types of thyroid disease, including 19 questions that check the condition of the disease Hyper, 30 check the disease Hypo, 14 for Hash's, 23 for Grave's disease, and 9 for Node as shown in Table 1.

c. System inference mechanism

The inference mechanism is the expert mind of the system and is the control structure or rule interpreter. This component is essentially a computer program that provides a methodology for thinking about the information in the knowledge base and formulating recommendations.

The system is a reasoning mechanism that prepares its ability to think. Knowing that all experience is stored in the knowledge base (database), and that the system can communicate with databases, and then reprogram the system so that it can make inferences, and the mechanism used in this system is forward chaining, which is one of the methods of Rule-based experience systems Based Expert System to represent knowledge. Knowledge is represented using rules represented in an IF (Condition) THEN (Action) or a set of conditional statements. The inference machine compares each rule stored in the knowledge base with the facts in the database. And it continues forward with this data until the goal is achieved. Every time a rule is implemented, a new fact is added in the knowledge base according to the situation, and so on until the end of all the rules to finally represent a diagnosis of a new situation and save it as a new fact in the database. And using Certainty Theory (CF) [16], which can generate a true factor to calculate the percentage of each type of thyroid disease (Hypo, Hyper, Hash, Grave and Node).

Knowledge base description

The inference engine consists in obtaining the knowledge represented by the symptoms and causes of the types of thyroid disease that are represented in the knowledge base in the form of rules, after verifying its validity and safety by experts, after obtaining the knowledge base, it was saved in the database to represent the inference engine shown in the table next one:

Each question represents a diagnosis of each of the five types of thyroid disease (Hypo, Hyper, Hash, Grave and Node) and the answer is either yes or no compared to the case stored in the knowledge base shown in Table 1.

TABLE 1. Description of the Inference engine of knowledge base for thyroid

No	Question (Rule)	Why (Recommendation)	Hyperthyroidism (Hyper)	Hypothyroidism (Hypo)	Hashimoto's Disease (Hash)	Grave's Disease (Grave)	Thyroid nodules (Node)
1	Are you experiencing weight loss despite normal eating habits?	"If you are losing weight, you may have Hyper, Grave, or Node thyroid disease".	**0**	**0**	**0**	**1**	**1**
2	Do you suffer from a fast or irregular heartbeat (palpitations)?	If you have a fast heartbeat, you may have hyper or grave thyroid disease.	**1**	**0**	**0**	**1**	**0**
3	Do you have a slight tremor in your hands or fingers?	"If you suffer from mild tremors in the hands or fingers, you may have Hyper, Grave, or Node thyroid disease".	**1**	**0**	**0**	**1**	**1**
4	Do you have mood swings, nervousness, anxiety, irritability or tension?	"If you suffer from mood swings, you may have Hyper, Hypo, Grave or Node thyroid disease".	**1**	**1**	**0**	**1**	**1**
.	.	.	.			.	.
.	.	.	.			.	.
.	.	.	.			.	.
44	Do you suffer from changes in the menstrual cycle and fertility?	"If you feel changes in your menstrual cycle and fertility, you may have Hyper, Hypo or Grave Thyroid Diseases".	**1**	**1**	**0**	**1**	**0**
45	Do you suffer from muscle weakness, fatigue, fatigue and lethargy?	If you suffer from muscle weakness, fatigue and exhaustion, there is a possibility that you have thyroid diseases of all kinds	**1**	**1**	**1**	**1**	**0**
46	Do you suffer from increased sensitivity to heat?	"If you suffer from hypersensitivity to heat, you may have hyper or grave thyroid disease".	**1**	**0**	**0**	**1**	**0**
47	Have you noticed dryness, thinning and excessive hair loss?	"If you suffer from dryness, thinning and excessive hair loss, you may have Hyper, Hypo or Hash thyroid disease".	**1**	**1**	**1**	**0**	**0**

An example, when all cases of hyperthyroidism are met, it means that the patient is 100% infected with hyperthyroidism, but if all cases are met except for one case that denies the case in the knowledge base, this means that the patient is infected with a percentage of 95 % with hyperthyroidism. That is, an average of 18 correct answers, one interview, one wrong answer, divided by the total number of test questions for Hyper disease, which is 19 questions that are stored in the knowledge base. If, however, 12 offers are valid, except for 7 that negate the case in the knowledge base, this means that the patient has 63% of thyroid disease of the type Hyper, and so on for other types of disease. Determining that and comparing it, we get a percentage for each disease that shows the incidence of each disease. The ratio is calculated according to the following equation:

$$CF = \frac{Number\ of\ successes\ (the\ answer\ matches\ the\ knowledge\ base)}{Total\ total\ number\ of\ rules\ (questions)} \times 100$$

In this case, the number of success cases is calculated each time according to the counter with decreasing the failure case to get the correct total number of success times, as the failure case means that the answer does not match the knowledge base.

As shown in Table 1, all cases are represented by a value of 1, which means that the true rule is True for the case, and its value is 0, which means that the rule is incorrect. 0 and the comparison with the knowledge bases, where three counters were set, each counter counting the success cases for each disease, from which the result is shown according to the previous equation to clarify the result of the diagnosis.

5. Discussion and Results

After completing the data analysis stage and determining the functions that the system will perform, the system was designed according to the analyzed data that was collected by various data collection methods, which were organized according to the appropriate database for storage and retrieval as needed. The following is a presentation of the main tables used in building the system, Table 2. and Table 3. representing the patient's data and a table describing the inference mechanism in the knowledge base.

TABLE 2. Patient Data

No. Patient	Name, Patient	BirthDay	Sex	Nation	Date	Address	Result-Hyper	Result -Hypo	Result -Hash	Result - Grave	Result -Node

TABLE 3. Knowledge Base for Describing The inference mechanism

No. Question	Question	Why	How	Hyper	Hypo	Hashimoto	Grave	Nodules	Recommendations

The process of implementing the system, in which the picture became completely clear to the system, the system was run and tested, and the system requirements and various designs were converted into a complete system that serves all the requirements prepared for it without errors.

Testing the system was carried out by reviewing the component procedures for the study, displaying the system interfaces, ensuring that they work correctly, testing the software components in the form of independent units, and making sure that they perform all the procedures for which this system was established. And then testing the system as a whole according to the functional and performance test on 92 cases of different nationalities, in which it was confirmed that the system performs the required image of it and the result was 14 cases diagnosed with type Hyper, 31 diagnosed with Hypo type, 11 diagnosed with Hash type, 13 diagnosed cases Grave and 23 Node cases with 14 misdiagnosed errors. The system tools used were confirmed to perform their work effectively and efficiently, with an accuracy of 85%, to be an integrated system for diagnosing thyroid disease.

TABLE 4. The obtained accuracy by proposed system with Rule-based and TDI-EFL experts

Proposed system	Rule-based expert	TDI-EFL expert
85%	97%	85.33

Table 4. illustrates the results obtained by the proposed system and other system identify in the literature review in term of diagnosing accuracy for thyroid disease. The best results are presented and compared with an ambiguous rule-based expert system for diagnosing thyroid disorders in [12]. The results showed that the system based on the designed rules works well in predicting thyroid disorder with an accuracy of 97%. It was also compared with TDI-EFL expert system based on symptoms and tests used to diagnose the disease achieved an accuracy of 85.33%. Therefore, the proposed system result indicates 85% less accuracy in term of representing five different thyroid diseases compared to other algorithms used two to three thyroid diseases for diagnose disease.

After designing the expert system and entering the necessary data for the system, the evaluation stage came, in which a questionnaire was presented to some people in the medical field. A group of patients were tested on the system by some specialists in thyroid diseases, by allowing them to use the system and express their opinion. Where the system was presented to 137 users of different specialized groups, they were satisfied with the system by 79%, and the system was completed to help specialists in medical institutions to diagnose epidemic thyroid disease based on expert systems based on production rules.

6. Conclusion

Expert systems in the field of medical diagnosis are important and most effective in providing advice or making decisions. The expert system includes a large volume of knowledge in a

particular field. The knowledge comes from an empowered expert who is able to reach a successful diagnosis in the expertise field. This study presented an expert system to simulate the mental capabilities of medical experts in the field of thyroid disease through the use of computer systems. The medical knowledge is represented in the form of rules and facts are controlled within knowledge bases. The study aims to build a system that has the ability to simulate the experience of doctors to diagnose 5 types of thyroid disease (Hypo, Hyper, Hash, Grave and Node), to provide a solution to difficult problems that need expert advice in solving them. The system has been developed, tested and ensured that it works as intended, with 85% diagnostic accuracy on 92 cases. The expert system was evaluated by submitting a questionnaire and presenting it to different categories of specializations and applying it to samples of patients' cases. The result was 79% effective, that the study worked to achieve the goals for which it was designed. In seek to put this system as an application available on the Internet, so that patients can use it in the absence of specialized doctors.

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