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Original Article

Expert System to Help Doctors in the Process of Bacteriological Diagnosis with Pre-Laboratory Screening Diagnose Certain Negligible Diseases such as Pulmonary Tuberculosis in an Under-Equipped Country

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Abstract - This article presents a new program which helps doctors to make a bacteriological diagnosis of tuberculosis in under-equipped countries. According to the WHO's annual report in 2018, under-equipped countries are the most affected at 95%, particularly the South-East Asia region, with 44% new, and Africa at 28%. Due to the lack or insufficiency of doctors in the hospitals, they are confronted with many problems. To remedy this situation, a system based on knowledge and rules has been set up to help the doctor in the bacteriological diagnosis process with pre-laboratory screening for pulmonary tuberculosis.

Keywords - Bacteriological diagnosis, Pre-laboratory, Screening, Pulmonary tuberculosis, Expert system

1. Introduction

A decision, every day is life, is always the center of the action. In medicine, the process of bacteriological diagnosis with pre-laboratory screening consists, among other things, in making a diagnosis, without going to the laboratory. Thus, many decision-support applications have been developed in the medical field. These applications are intended to help healthcare personnel in the process of bacteriological diagnosis with pre-laboratory screening.

Designing a system capable of imitating what humans do through knowledge and rules is not an old idea. It was with the term Artificial Intelligence arose in 1956 by John Mc Carthy that it all started. According to certain author sources in the 1970s, computing has advanced with the appearance of expert systems, which are tools capable of reproducing an expert's cognitive mechanisms in a particular field. This is one of the ways trying to achieve artificial intelligence. [4]. The objective of this approach is to ask one or more human experts to establish rules that describe their way of making decisions in a given situation. [2]

An expert system attempts to simulate or imitate the know-how of a human expert, the way of reasoning of an expert in a given well-defined and precise domain. This approach is also the provision of knowledge acquired through a process to users or experts in the field. They can perform both information processing and reasoning,

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which in medical terms means a diagnostic and therapeutic strategy. So the role of a medical expert system is to provide medical help in an appropriate form based on previously established symptoms.[3]

MYCIN is one of the first expert back-chaining systems that used artificial intelligence to identify bacteria causing serious infections. The MYCIN system has also been used to diagnose blood coagulation diseases. MYCIN was developed over five or six years in the early 1970s at Stanford University. Rule-based expert systems, derived from the work of Buchanan and Shortliffe on the system, aim to capture human expertise in terms of form-if-condition-then-action rules. MYCIN [5].

2. Diseases Considered

2.1. Tuberculosis

Tuberculosis is an infectious disease. An infectious disease is caused by bacteria that enter the body. For tuberculosis, it is Koch's bacillus. It is probably hard to know how you got tuberculosis. Anyone can get tuberculosis, regardless of age, race or gender. The disease can occur anywhere in the body; the most common form of tuberculosis is pulmonary tuberculosis[6], [7].

2.1.1. Pulmonary Tuberculosis

We speak of pulmonary tuberculosis when there is an active infectious focus in the lungs due to the fact that Koch's bacillus has settled in the lungs after being inhaled, and then the same causes an infection. When the focus of infection is large, many bacteria have multiplied, and these bacteria can be easily coughed up. A person with pulmonary tuberculosis often suffers from a prolonged cough and the production of mucus (sometimes with blood) [6].

2.2. Artificial Intelligence and Expert Systems

Artificial Intelligence, a field that mimics human behavior, first envisioned as a machine that might be indistinguishable from a human, has come a long way to now be realized in various areas of our daily lives. Indeed artificial intelligence is considered a revolutionary technology that would transform all aspects of human life. Defining artificial intelligence is not easy. Since its origins as a specific field of research in the middle of the 20th century, it has always constituted a frontier, incessantly pushed back. Artificial intelligence, in fact, designates less a well-defined field of research than a program founded around an ambitious objective: to understand how human cognition works and to reproduce; create cognitive processes comparable to those of human beings [8],[9]

An expert system is an artificial intelligence approach that simulates the reasoning and knowledge of one or more human experts. Expert systems are built for a very narrow domain with clearly defined and limited expertise. This makes the performance of the expert system entirely dependent on the right choice of human experts. Fig. 1 shows the expert system architecture in the medical field. ExpertTub is an expert system.

2.3. Expert System Architecture

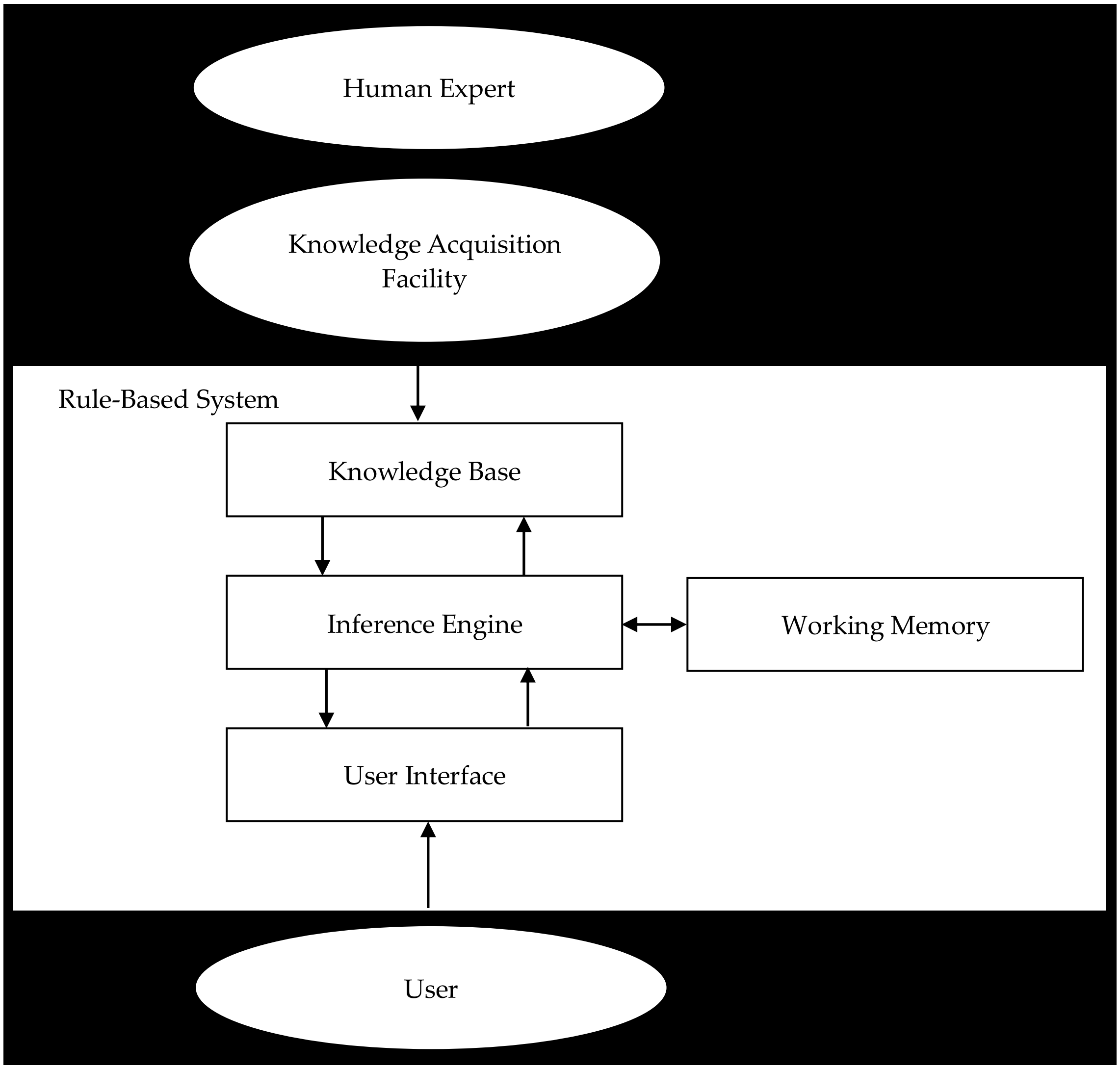

Fig. 1 The structure of an expert system in medicine

Source: author

3. Materials and Methods

In this article, we have developed an expert system, with Exsys Corvid software, to help the doctor in the bacteriological diagnosis of pulmonary tuberculosis.

Expert system = knowledge + problem - solving methods

For this, we have the following steps:

Phase 1: Identification of the problem

The first step is to identify the problems, which are: Slowness and insufficient staff, which may result in the death of the patient.

Phase 2: Acquisition of knowledge

We have collected information to help experts/doctors from the internet and refer to appropriate books on lung disease. Look for relevant information on lung diseases in underserved countries such as books, articles, the internet and more.

Phase 3: Knowledge representation

After receiving knowledge from doctors, we turned the same knowledge into rules. We were able to make a knowledge base with 6 rules.

Phase 4: Verification and Validation

The knowledge base created has been validated for the bacteriological diagnosis of pulmonary tuberculosis using symptoms and signs. All symptoms and signs have always been checked to ensure proper system operation.

Phase 5: Implementation

The Expert system, after validation, has been tested with Exsys Corvid, and the satisfaction of the physician is to see a result similar to that of the human expert.

Table 1. Expert's opinions on tuberculosis

+++ Highly Probable				
1º Team	**2º Team**	**3º Team**	**4º Team**	**5º Team**
Chronic fever Hemoptisia Transpiration Dispnea Weight loss	Chronic fever Hemoptisia Transpiration Dispnea Weight loss Cough>15 days Agitation	Chronic fever Hemoptisia Transpiration Weight loss Anorexy Astheny	Chronic fever Hemoptisia Transpiration Dispnea Weight loss Cough>15 days Anorexy Astheny	Chronic fever Hemoptisia Transpiration Dispnea Weight loss Cough>15 days Agitation Anorexy Astheny
++ Probable				
	Anorexy Astheny headache Malaise Chills	Cough>15 days Chest pain Dispnea	Tosse>15 dias Anorexy Astheny headache Malaise Chills Chest pain Dispnea	Dispnea Cough>15 days Anorexy Astheny headache Malaise Chills Chest pain
+ Less Probable				
		Chills Malaise		Cough<15 days Astheny Chills Malaise
- Improbable				

Source: Cabinda's Hospital

Table 2. Decision table

Conditions/Rules	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**Else**
Chronic fever	Y	Y	Y	N	N	N	
Hemoptisia	Y	Y	Y	N	N	N	
Transpiration	Y	Y	Y	N	N	N	
Weight loss	Y	Y	Y	N	N	N	
Dispnea	Y	_	Y	_	Y	N	
Cough>15 days	_	_	Y	_	Y	N	
Agitation	_	N	Y	N	N	N	
Anorexy	N	Y	Y	Y	_	N	
Chills	N	N	N	Y	_	Y	
Malaise	N	N	N	Y	_	Y	
headache	N	N	N	Y	_	N	
Astheny	N	Y	Y	Y	_	_	
Chest pain	N	N	N	_	Y	N	
Cough>15 days	N	N	N	N	N	_	
Actions							
+++ Highly Probable	X	X	X				
++ Probable				X	X		
+ Less Probable						X	
- Improbable							X

Source: Author

Table 3. Simplification decision table

Conditions/Rules	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**Else**
Chronic fever	Y	Y	Y	N	N	N	
Hemoptisia	Y	Y	Y	N	N	N	
Transpiration	Y	Y	Y	N	N	N	
Weight loss	Y	Y	Y	N	N	N	
Dispnea	Y	_	Y	_	Y	N	
Cough>15 days	_	_	Y	_	Y	N	
Agitation	_	N	Y	N	N	N	
Anorexy	N	Y	Y	Y	_	N	
Chills	N	N	N	Y	_	Y	
Malaise	N	N	N	Y	_	Y	
headache	N	N	N	Y	_	N	
Astheny	N	Y	Y	Y	_	_	
Chest pain	N	N	N	_	Y	N	
Cough>15 days	N	N	N	N	N	_	
Actions							
+++ Highly Probable	X	X	X				
++ Probable				X	X		
+ Less Probable						X	
- Improbable							X

Source: Author

In this article, we have used forward chaining, as shown in Fig. 2, which is a process used by the expert System to answer user questions. This process is used to manage tasks such as creating a conclusion or result from facts.

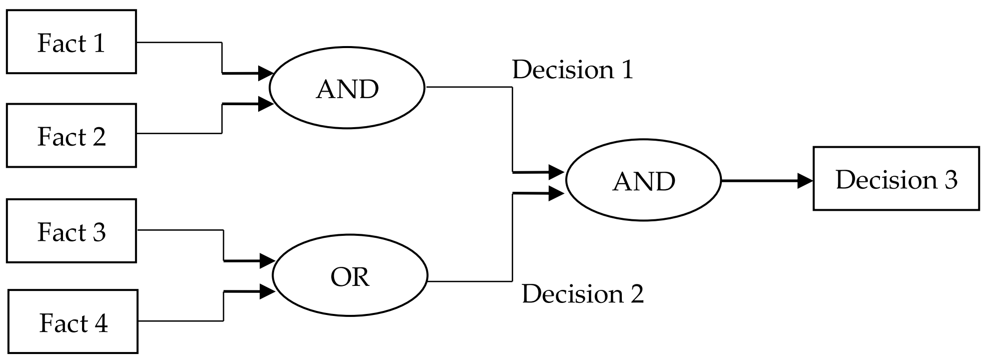

Fig. 2 Forward chaining

Source: Author

3.1. System Modeling

A picture is worth more than a long speech. This proverb summarizes the origin of schematization in Unified Modeling Language (UML) was invented. UML is a modeling system that provides a set of conventions used to describe a software system in terms of objects. The Unified Modeling Language (UML) was designed to be a common, semantically and syntactically rich visual modeling language. It resembles plans used in other fields and consists of different types of diagrams. Overall, UML diagrams describe the boundary, structure, and behavior of the system and the objects within it. [11], [12].

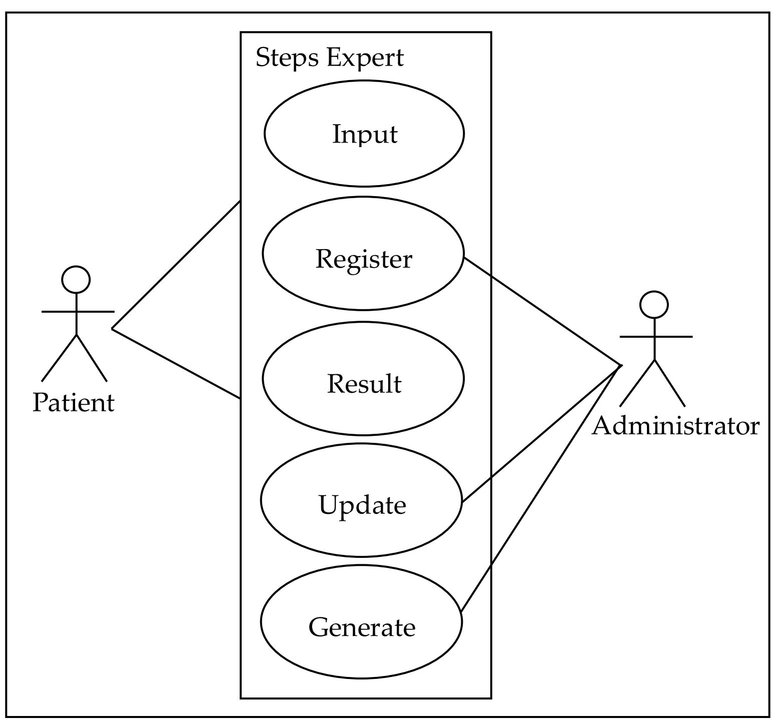

Fig. 3 Users case diagram of experttub

Source: Author

Table 4. Users case description

USE CASE NAME	DESCRIPTION	ACTOR(S)
Register	This describes the first event that must occur for a user to have access to the Expert System.	Administrator
Input	This describes the event where the user inputs the symptoms or signs.	Patient
Result	This use case describes the scenario where the user is being diagnosed and receives the answer.	Patient
Update	This describes the step where the Administrator updates the database in terms of the symptoms and prescription tables.	Administrator
Generate	A summary of daily use of the system is generated	Administrator

Source: Author

4. System Test Interface, Graphics

4.1. Implementation

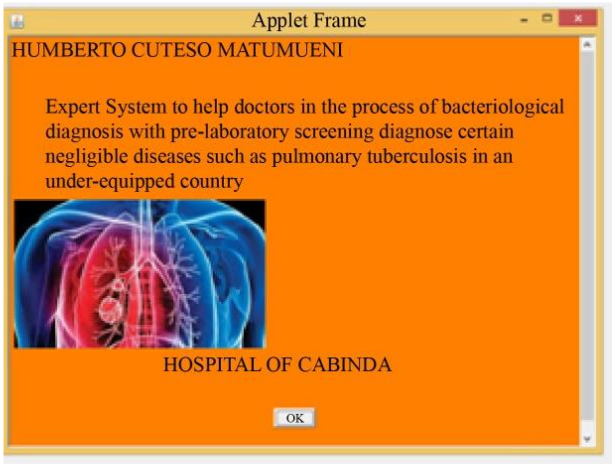

Fig. 4 Interface of experttub

Source: Author

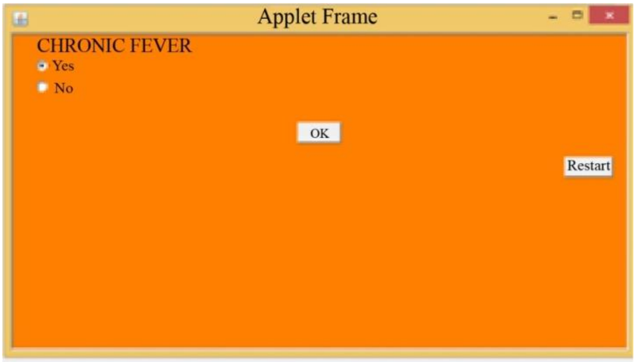

Fig. 5 Input dados or symptoms in experttub

Source: Author

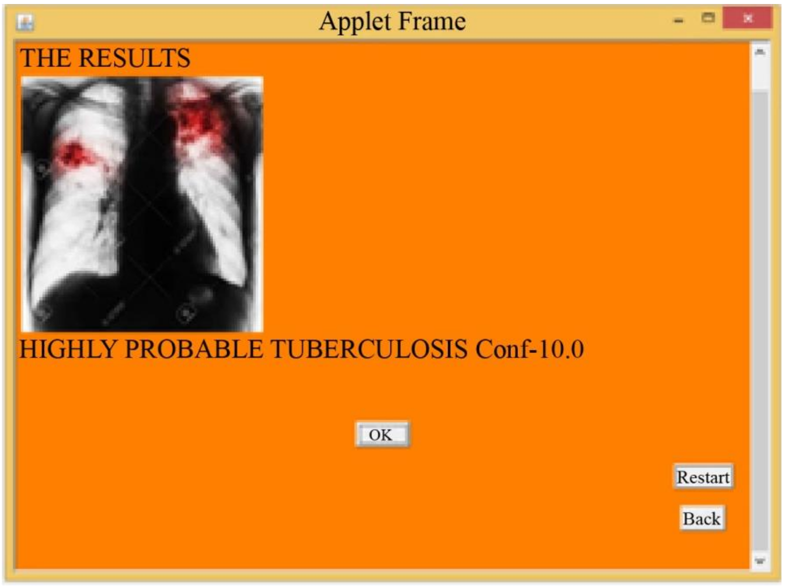

Fig. 6 The result of experttub

Source: Author

The ExpertTub system has been designed for the purpose of establishing a differential diagnosis; developing a list of possible issues that may be causing a patient's signs and symptoms – is an important part of clinical reasoning.

A summary of the test case results above:

Table 5. Summary of results

		Result ExpertTub		
		Yes	No	Total
Result Physician	Yes	70	12	82
	No	20	83	103
	Total	90	95	185
	Pob.	0.82		
	Pexp.	0.5		
	K.Cohen	0.64		
	Substantial	0.61 — 0.80		

Source: Cabinda's Hospital

Table 6. Results of evaluation (Tuberculose pulmonaire)

Cases Tested	Cases Successful	Cases Partially Successful	Cases Unsuccessful	Aproximated Percentage of Success
ExpertTub				
Test Cases				
pulmonary tuberculosis	70	32	83	185

Source: Cabinda's Hospital

5. Discussion of Results

An agreement between judgments is defined as the conformity of two or more pieces of information related to the same object. The rate of agreement or "concordance" is therefore estimated by the Kappa coefficient proposed by Cohen [3].

Here we want to assess the degree of agreement between the positive and negative diagnoses provided by two groups (Doctors) and another (ExpertTub) looking for results of pulmonary tuberculosis on the same patients.

The study involves 185 patients, and the results are presented in Table I. According to the calculation of Cohen's Kappa was carried out to check the agreement of the result between the observers and the concordance. Cohen's Kappa was introduced to give a level of agreement between the result of the doctor and the human expert. Cohen's Kappa is commonly used to measure the degree of agreement between two sets of scores. Cohen's Kappa (k) is then defined by the formula [3]:

$$\text{Kappa} = \frac{\text{Observed Agreement} - \text{Expected Agreement}}{1 - \text{Expected Agreement}}$$

5.1. Validation of Results

In the 185 cases tested, we see the results presented in Table 5, which determines the following kappa value (k = 0.61 – 0.80). The value of Kappa presents a result of a moderate diagnosis of pulmonary tuberculosis carried out in the hospital of Cabinda.

6. Conclusion

The Expert System is designed to assist physicians in the bacteriological diagnosis of tuberculosis under-equipped, not to replace physicians. In this article, we collected information from doctors during their practice; we do not use only their theoretical knowledge but also their acquired experience. Indeed the expert's knowledge is extracted and stored, and it can be used to help the expert in case of absence. To this end, case-based reasoning should be exploited for medical decision support. We based our approach on case-based reasoning, a problem-solving paradigm based on past experience. Case-based reasoning allowed us to optimize time, given that time is an important factor that should not be overlooked in the medical field. Furthermore, physicians are often faced with critical questions that require decision-making. However, the amount of data generated in healthcare organizations is constantly increasing. Thus, we have resorted to creating an expert system based on the medical rule. We hope that the proposed system, with the aim of helping to reduce the deficiencies of doctors, facilitates decision-making on diagnosing pulmonary tuberculosis. We proposed an expert system based on expertise optimized in a table and reasoning from cases called ExpertTub. Subsequently, we tested 185 new real cases of tuberculosis, where the result of the system was estimated as moderately correct on real cases of tuberculosis patients.

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