Asian Journal of Research in Computer Science

11(3): 35-43, 2021; Article no.AJRCOS.73302
ISSN: 2581-8260

Rule-Based Expert System for Assist Physician to Diagnosis of Malaria: XPerMal

Humberto Cuteso Matumueni[1*]

[1]Polytechnics Superior Institute of Soyo, Angola.

Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/AJRCOS/2021/v11i330265
Editor(s):
(1) Dr. Hasibun Naher, BRAC University, Bangladesh.
Reviewers:
(1) B Sankarasubramanian, Jawaharlal Nehru Technological University, India.
(2) Mohamed I. Marie, Helwan university, Egypt.
Complete Peer review History: https://www.sdiarticle4.com/review-history/73302

Original Research Article

Received 28 June 2021
Accepted 02 September 2021
Published 07 September 2021

ABSTRACT

Nowadays, common diseases like malaria, typhoid and cholera become more dangerous problems for people living in this world. The objective is how it can avoid the queue of patients in hospital. In this article, the author has proposed a model of expert systems using the knowledge of physician and other health professionals. The rule based expert system XPerMal useful for patients infected with common diseases and this system will give an answer as similar to a doctor or medical expert and also this system is very useful in rural areas where we have young medical experts or have no medical expert. The reasoning strategy is a key element in many medical tasks. It is well known that developing countries face a shortage of medical expertise in the medical sciences. Patients also find a huge queue in hospitals. Because of this, they are unable to provide good medical services to their inhabitants. The knowledge is acquired from literature review and human experts in the specific field and is used as a basis for analysis, diagnosis and decision-making. Knowledge is represented by an integrated formalism that combines rules and facts.

Keywords: Health; disease; rule based expert system; knowledge based system; Exsys Corvid; XPerMal.

1. INTRODUCTION

Rule Based Expert Systems is programs that come from the computer science branch called Artificial Intelligence, which has the ability to minimize the human being, to make judgments and to reason according to certain facts and rules. In remote areas, the population is deprived

**Corresponding author: E-mail: hkuteso@hotmail.com;*

of health professionals and experts to diagnose the disease. It is therefore necessary to store the expertise of specialists or doctors using the System Expert computer technology. Medical artificial intelligence is mainly concerned with the construction of artificial intelligence programs that perform the diagnosis of patients [1].

After that, they can consult the specialist doctor if it is necessary or serious. A rule-based expert system includes both artificial intelligence techniques, such as knowledge-based systems or expert systems. Medical knowledge is composed of symptoms-illness, inter-symptom and inter-disease relationships. One of the main elements of this system is the inference engine that essentially interprets patient information using medical knowledge before giving a result [2].

1.1 Diseases Considered

1.1.1 Malaria

Today in the world and mainly in Africa, malaria is one of the most flails of the century. Research has shown that malaria kills an estimated one million, two hundred thousand every year, nearly double the estimated six hundred fifty-five thousand people in 2009.

Malaria is characterized by a fever caused by a parasite transmitted by the anopheles mosquito carrying malaria, become resistant to certain treatments and many insecticides [3],[4].

1.1.2 Cerebral malaria

Cerebral malaria is the most complicated type of complicated malaria of Plasmodium falciparum malaria infection. It is a clinical syndrome characterized by coma and asexual forms of the parasite on peripheral blood smears. With a high mortality rate and some surviving patients suffer brain damage that is manifested by long term neuron cognitive deficits.

Cerebral malaria is the most severe neurological manifestation of severe malaria. With an incidence of one million and one hundred and Medical expert system twenty or one million of year in endemic areas of Africa, children in this region are the most affected. In Africa, the highest incidence is among preschool children and at least 575,000 children each year. Recent reports, however, suggest that the incidence of severe malaria is declining. [3],[4].

A century and a half ago, computer tools for medical decision-making and several algorithms were developed and built to build applications of the expert medical system for a variety of medical specialties.

A physician is required to remember and apply the knowledge of a wide range of entities such as disease presentations, diagnostic parameters, drug combinations and guidelines.

1.1.3 Rule-based expert system

An expert system, based on rules, aims to capture the human expertise in terms of the rules of form if condition then action. MYCIN, developed in 1977 by Shortliffe at Stanford, is one of the first known rules-based systems. Rule-based systems emphasize the use of decision rules for inference. It is possible that a set of rules can be used to capture knowledge of the relevant domain of a human expert and can then be used to replicate the problem-solving of the expert in this field.[5].

1.1.4 The expert system and knowledge base

The expert system and Knowledge base for more detail and because of the limited perceived perception levels, the knowledge provided by experts has been often vague; a knowledge base derived from the data sets is more accurate in comparison to the knowledge base built from the data of experts. The knowledge base built using the automated approach captures empirical evidence from the data.

This approach aligns with evidence-based decision-making that emphasizes the use of empirical evidence to make clinical decisions.[6].

2. METHODS

The purpose of this research is to help the physician to use an expert system capable of correcting certain limitations associated with the manual method of diagnosing diseases. A rule-based expert system is a system that contains a rule base for describing certain models.

The rule-based approach uses rules of type If - Then. The researchers focused on more recent publications, and a series of methods were used to identify the reasoning process in medical tasks. The application of the methods has been extended, encompassing empirical studies of expert-novice differences in the resolution of patients' medical problems [7].

Physicians generally respond by considering the patient's signs and symptoms in terms of potential diagnoses, not the underlying mechanisms of the disease. In diagnostic explanation tasks, physicians were asked to explain the path physiology of a patient's condition.

1. If (headache and chills and acute fever or Arthralgia) Then More probable Simple Malaria.
2. If (an arthralgia and acute fever or headache or chills) Then More probable Simple Malaria.
3. If (headache and arthralgia and chills and acute fever and myalgia) Then More Probable Simple Malaria
4. If (nausea or anorexia or asthenia or acute fever or vomiting) Then Probable Simple Malaria.
5. If (headache) Then Probable Simple Malaria
6. If (acute fever and vomiting or headache or anorexia or asthenia or nausea) Then Probable Simple Malaria
7. If (asthenia and nausea and vomiting) Then Little Probable Simple Malaria
8. If (anorexia and nausea) Then Not Probable Simple Malaria

1. If (convulsion and acute fever and delirium) Then More probable Cerebral Malaria.
2. If (convulsion and delirium and coma and yellowish eyes and arthralgia and bewilderment or dizziness' or stupor) Then More probable Cerebral Malaria.
3. If (convulsion and acute fever and delirium and coma and stupor or headache or agitation) Then More probable Cerebral Malaria
4. If (asthenia or acute fever or agitation or vomiting or chills or malaise or anorexia or pallor) Then Probable Cerebral Malaria
5. If (acute fever and agitation and dizziness) Then Probable Cerebral Malaria.
6. If (acute fever and agitation or convulsion or delirium or malaise or headache or coma or stupor) Then Probable Cerebral Malaria.
7. If (vomiting and nausea and chills and malaise) Then little Probable Cerebral Malaria.
8. If (nausea and anorexia) Then Not probable Cerebral Malaria.

2.1 Literature Survey

An expert system is a branch of artificial intelligence, and was developed by the artificial intelligence community in the mid-1960s. An expert system can be defined as an intelligent computer program that uses a knowledge base and an inference engine to solve sufficiently complex problems that require significant human expertise for their solutions [5]. Then the expert system can make inferences and come to a specific conclusion to give advice and if necessary explain the logic. From this definition, we can deduce that expertise can be transferred from a human to a computer and then stored in a computer. Expert systems provide powerful and flexible ways to solve a variety of problems that often cannot be addressed by other, more traditional methods. The four main components of an expert system are: a knowledge base, an inference engine, a knowledge engineering tool, and a user interface [8],[2]. Expert system is applications in many fields, and they are especially suited in situations where the expert is not readily available. To develop an expert system, knowledge must be extracted from the domain expert. Knowledge is a theoretical or practical understanding of a subject or field.

An Expert System is a system that can diagnose diseases by checking for symptoms and signs. All health professionals, including physicians, medical students and pharmacists can update their knowledge of causes and treatment.[9],[10].

This knowledge is then converted into a computer program. The knowledge engineer performs the task of extracting knowledge from the domain expert.

Rule-based expert systems are the best-known type of knowledge-based systems. Knowledge is represented in the form of If -Then rules.

Nowadays, expert systems have been widely used in almost every area of human expertise to help users make decisions. The main purpose of medical artificial intelligence is to build artificial intelligence programs that perform the diagnosis and make recommendations for therapy. Expert medical systems are more likely to be found in clinical laboratories and educational settings, for clinical surveillance, or in data-rich areas such as the environment. What is now realized is that, if they fulfill an appropriate rule, smart programs do offer significant benefits [10],[7],[1].

Table 1. Expert's opinions of simple malaria

Simple malaria				
More probable				
1º Group	2º Group	3º Group	4º Group	5º Group
acute fever headache chills	acute fever headache chills arthralgia	acute fever chills arthralgia	acute fever headache arthralgia	Acute fever headache chills arthralgia myalgia
Probable				
Acute fever nausea	Anorexia asthenia nausea vomiting	headache	acute fever vomiting	acute fever anorexia asthenia headache nausea vomiting
Little_ probable				
Asthenia vomiting nausea		Asthenia vomiting nausea		Asthenia vomiting nausea
Not_ probable				
		Anorexia nausea		

Table 2. Decision table

Conditions/Rules	R1	R2	R3	R4	R5	R6	R7	R8
headache	Y	—	Y	N	Y	—	N	N
anorexia	N	N	N	—	N	—	N	Y
arthralgia	—	Y	Y	N	N	N	N	N
asthenia	N	N	N	—	N	—	Y	N
chills	Y	—	Y	N	N	N	N	N
acute fever	Y	Y	Y	—	N	Y	N	N
myalgia	N	N	Y	N	N	N	N	N
nausea	N	N	N	Y	N	—	Y	Y
vomiting	N	N	N	—	N	Y	Y	N
Actions								
More_ probable	X	X	X					
Probable				X	X	X		
Little_ probable							X	
Not_ probable								X

Table 3. Expert's opinions of cerebral malaria

Cerebral Malaria				
More probable				
1º Group	**2º Group**	**3º Group**	**4º Group**	**5º Group**
Convulsion Delirium	Convulsion Delirium Coma	Convulsion Delirium Coma Stupor	Convulsion Delirium Coma	Convulsion Delirium Coma
Acute fever	Dizziness	Bewilderment	Acute fever	Acute fever Stupor Agitation
	Arthralgia Yellowish eyes		Stupor	headache
Probable				
Acute fever Agitation	Malaise Vomiting Asthenia Chills	Acute fever Agitation Dizziness	Acute fever Agitation	Acute fever Agitation Vomiting Malaise Chills Asthenia Pallor
Asthenia	Anorexia Pallor		Malaise	Anorexia Yellowish eyes
Little probable				
Malaise Vomiting		Malaise Vomiting headache	Malaise headache Asthenia	Dizziness Vomiting Nausea Chills headache
Nausea Chills		Pallor Arthralgia		Asthenia Pallor Arthralgia Anorexia
Not probable				
		Anorexia Nausea		

Table 4. Decision table

Conditions/Rules	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**
Convulsion	S	S	S	N	N	-	N	N
Acute fever	S	N	S	-	S	S	N	N
Delirium	S	S	S	N	N	-	N	N
Agitation	N	N	-	-	S	S	N	N
Asthenia	N	N	N	S	N	N	N	N
Vomiting	N	N	N	-	N	N	S	N
Nausea	N	N	N	N	N	N	S	S
Chills	N	N	N	-	N	N	S	N
Malaise	N	N	N	-	N	-	S	N
headache	N	N	-	N	N	-	N	N
Dizziness	N	-	N	N	S	N	N	N
Coma	N	S	S	N	N	-	N	N
Yellowish eyes	N	S	N	N	N	N	N	N
Anorexia	N	N	N	-	N	N	N	S
Pallor	N	N	N	-	N	N	N	N
Stupor	N	-	S	N	N	-	N	N
Arthralgia	N	S	N	N	N	N	N	N
Bewilderment	N	S	N	N	N	N	N	N
Actions								
More probable	X	X	X					
Probable				X	X	X		
Little probable							X	
Not probable								X

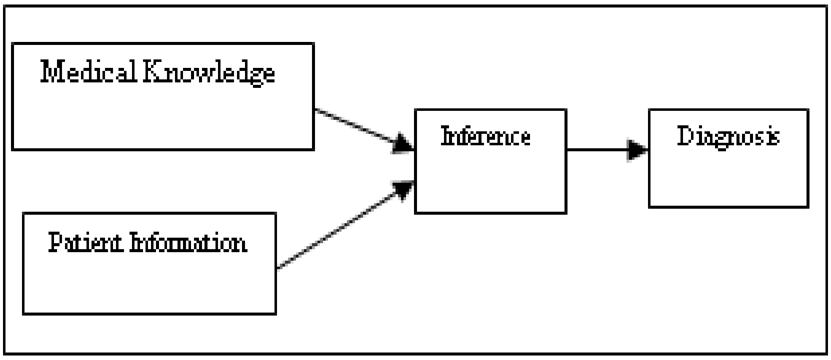

Fig. 1. Model of expert system medical for diagnosis

2.2 Decision Table

A decision table represents an exhaustive set of conditional expressions, in a predefined problem area. [11].

A decision table is a tabular representation used to describe and analyze procedural decision situations, where the state of a number of conditions determines the execution of a set of actions. However, not just any representation, but one in which all the separate situations are presented as columns in a single table, so that all possible cases are included in one and only one column (entirety and exclusivity).

Converting Decision Tables to a Rule Set

In many cases, converting to a single decision statement is not flexible enough to handle knowledge in the knowledge base. One might prefer to transform the decision table into a set of rules. Several alternatives are available:

1. Translation based on entry (x) generates a rule for each x in the (contracted) table.

This method leads to several rules with the same premises, but different conclusions, if more than one action is to be taken for a certain combination of attributes.

Column-based translation generates a rule for each column in the decision table. All actions resulting from a specific combination of conditions will be included in a rule. The rules can even be combined further. It's interesting because every possible situation is represented by a rule.

To arrive at a correct knowledge base without redundancies or repetitions in doctors' reasons, we used two instruments, a sheet to have the reasons of each doctor and a decision table to avoid repetition and contradiction in the answers of doctors such as shows Table 1,2,3 and 4.

The hyphen means the contradiction between the reasons of doctors on an answer, to resolve this contradiction we have used the hyphen which means yes or not.

2.3 System Modeling

UML is a modeling system that provides a set of conventions used to describe software in terms of objects. It offers diagrams that provide different perspective views of the parts of the system that the author claims to develop. Use case diagrams play a major role in the design of the system, as they serve as a road map for the construction of the system structure. It also defines the different part that will use the system and how the user can interact with the system. A use case diagram graphically represents the interactions between the system, the external system and the user [12].

2.3.1 Implementation of rule based expert system XPerMal

Generally, patients visit hospitals to complain about their symptoms and signs, and the user of XPerMal questions patients about their symptoms and signs and looks for symptoms and signs in the knowledge base. If the symptoms match what is in the knowledge base, the user gives the result or pathology to the patient.

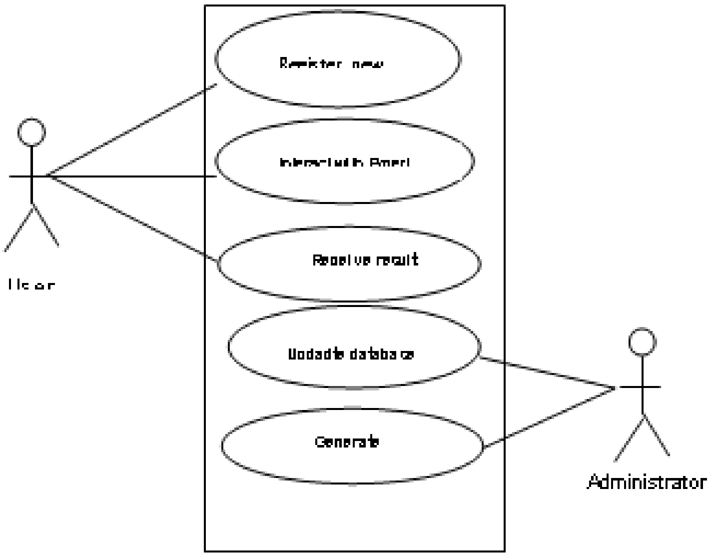

Fig. 2. Use case diagram of expert system

Fig. 3. Exsys Corvid

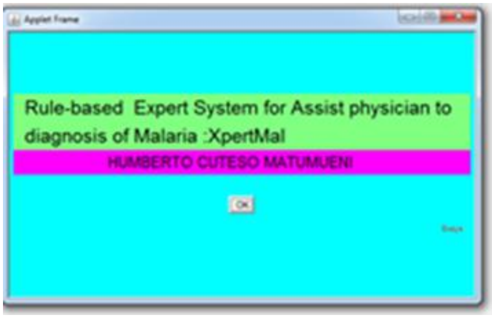

Fig. 4. Screen of expert system

Fig. 5. Input data of patient

Fig. 6. Report page of result consultation patient xpermal

Table 5. Comparison between human and expert system

	Cases Tested	Cases Successful	Cases Partially Successful	Cases Unsuccessful	Approximate Percentage of Success
XPerMAL Test Cases					
Simple Malaria	75	70	3	2	93,3
Cerebral Malaria	19	16	2	1	84,2

3. RESULTS AND DISCUSSION

A summary of results for the above test cases and case studies is shown below:

As noted above, the proposed system of experts is working satisfactorily, with a success rate of about 93.3% and 84.2% in real cases. The proposed expert system has made it possible to select the symptoms and a sign of the patients and to diagnose them as a physician, but it does not work well in particular cases outside its field of knowledge.

It will be possible to improve the success rate in real cases as new knowledge is discovered and incorporated into the knowledge base. It will be possible to improve the success rate in as new knowledge is discovered and incorporated into the knowledge base.

4. CONCLUSION

XPerMal has been found useful in today's world thanks to technology. When an expert's knowledge is extracted and stored, that knowledge can be used to replace the expert in the event of death. The medical diagnosis will have a greater part of the advantages of the expert system, knowing that only a few specialties exist in the medical field. The knowledge of such a specialist can be reproduced and used in case of extreme necessity. In this article, a rule-based medical expert system is developed and tested to address the different challenges of the traditional method of diagnosing diseases. The researchers hope that XPerMal is a useful, the proposed system and a tool that can help them reduce the queue and provide accurate diagnosis from patients' symptoms and signs. The structure of knowledge was represented by a case formalism. Malaria assesses the performance of the system by testing it for almost 75 new cases of uncomplicated malaria and 19 new cases of cerebral malaria, where the system has been able to estimate the correct diagnosis. For future work, more cases will be added to the case memory, and it can be tested.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Waterman, Donald A. A guide to expert systems. Addison-Wesley Publishing Company, Inc;1956.
2. Hamed, Gehad Mohammed. An expert system for concrete diagnosis. MAI,Vol. 32-03, King Fahd University of Petroleum and Minerals, Saudi Arabia;1983.
3. Wikipedia. Malaria;2012. Retrieved 10th January, 2018 Available:http://en.wikipedia.org/
4. Guardian. Malaria deaths research;2012. Retrieved 31st February, 2018 Available: http://www.guardian.co.uk/
5. Wilkins, Andrew John. The application of expert systems techniques in the design of durable concrete. DAI.1991;54-02C, Aston University, United Kingdom.
6. De Brito J, Branco FA, Ibanez M. "A knowledge-based concrete bridge inspection system. Concrete International. United States.1994;16.
7. Luger, George F, Stubblefield William A. Artificial Intelligence and the Design of Expert Systems", The Benjamin/Cummings Publishing Company, Inc;1989.
8. Russell S, Norvig P. Artificial intelligence: A modern approach, prentice hall, second edition;2002.
9. Durkin J. Expert system: Design and development. Macmillan publishing company Inc, New York;1994.
10. Giarratano, Joseph, Riley, Gary. Expert Systems: Principles and Programming. PWS-KENT Publishing Company, Boston;1989.
11. Vanthienen J. Acquisition et validation de connaissances à l'aide d'une table de decision Engineering Workbench, The World Congress on Expert Systems, Pergamon Press,Orlando (Floride).1861-1868.
12. Miller R. Practical UML: A hands-on introduction for developers. Available: http://edn.embarcadero.com/

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle4.com/review-history/73302