Literature Synthesis: Knowledge-Based Expert Systems for Medical Advice Provision

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ABSTRACT

Expert systems are used extensively in many domains ranging from medicine to science and space technology (1,2). This paper discusses the use of medical expert systems in rural areas. Many rural communities have an extremely limited access to medical advice. People travel long distances to clinics or medical facilities and there is a shortage of medical experts in most of these facilities. This results in slow service and patients end up waiting long hours without receiving any attention. This problem can be solved by creating a system that can give advice for common conditions such as diabetes and hypertension. Hence medical expert systems can play a significant role in such cases where medical experts are not readily available. The purpose of this paper is to analyse the role that these systems can play in improving the situation.

Keywords: expert system, medical advice

1. INTRODUCTION

Expert systems are a branch of applied artificial intelligence (3). An expert system is an intelligent computer program which captures the knowledge of a human expert (4). This information is then used to solve real-world problems in an automated fashion (5).The basic idea behind these systems is simply that expertise on a specific subject is transferred from a human to a computer(3). The main purpose of knowledge-based expert systems is to make the knowledge of a human expert and their experiences to be more commonly available, particularly in areas where they are not readily available(6). The quality, efficiency, and competitive control of expert system operations have increased over the years (4). Expert systems are applied in many different areas (1). In medicine expert systems are used to diagnose a medical problem and predict particular diseases (5), as well as to assist a physician in diagnosing medical problems of a patient or help interpret medical test results (4). Some of these systems are designed to train medical school students.

In chemistry expert systems are used to help interpret data from an experiment and they can assist in the planning and monitoring of the experiments and interpreting test data. They are very useful in determining molecular structures from mass spectrogram data (4). Whereas in computer science expert systems are used to assist in solving time consuming tasks (7). They are also used to design and diagnose a variety of computer systems (4).

2. MEDICAL EXPERT SYSTEM

In medicine, building and sharing knowledge about new theories, as well as advancing technologies and discoveries is of major concern (8). In this respect there is a need for physicians to be provided with efficient tools that offer target access to other knowledge such as medical statistics and expert opinions (8). Most medical expert systems applications are very useful for predicting and diagnosing a particular disease and providing recommendations regarding therapy and

rehabilitation of the patient after therapy (5). They play a significant role where there are no medical experts available and in place where there is a shortage of hospitals, child health centers or dispensaries. However, medicine is a complex field and safety is a major issue. For this reason the lack of accuracy of information or systems can be a disadvantage (5). Medical expert systems play a significant role in providing support in common clinical problems like prediction of diseases, diagnosis of diseases, counselling of patients. All medical expert systems are in the form of a computer system (speech or text). The next section contains a brief description of three medical expert systems that played an important role in the success and development in the fields of expert systems.

2.1 MYCIN

MYCIN is a medical diagnosis expert system. It is designed to capture the expertise of a human expert on blood diseases (9). It is a rule-based system which uses production rules and backward chaining (9). It provides consultative advice to the user (physician or doctors) about the disease. It plays two main roles, namely identifying the most likely infectious diseases based on the patient's medical data provided and suggesting a prescription or treatment (10). It consists of three sub-systems: Consultation system, Explanation system and Rule acquisition system (9). The following section highlights strengths and weaknesses of this medical expert system.

Strengths:

- Does not overlook or forget details
- It considers every possibility (10)
- It provides a set of acceptable solutions or conclusions
- It provides accurate and quick diagnosis (11).

Weaknesses:

- Each "clinical visit" means new data
- Correctness of conclusion is not guaranteed because it is based on heuristics, but it uses Turing's test to judge correctness (10).
- Conciseness
- It is only available to diagnose infectious blood diseases (12).
- Bases advice on the data available at that particular time
- It does not follow up on previous decisions

Validity:

- It provides accurate and quick diagnosis (9)
- It operates using a simple inference engine and knowledge base system. Basically it will ask the user a set of yes/no queries. The program provides a list of possible diseases ranked from high to low based on the probability of each diagnosis. It then recommends drug treatment

2.2 ONCOCIN

ONCOCIN is a medical expert system tool that is designed to assist physicians in the treatment of cancer patients. It extends on the knowledge of MYCIN but provides high performance (13). Despite that it uses forward chaining; ONCOCIN uses the same rule-based approach as MYCIN. The main difference between the two systems is that MYCIN uses goal-driven reasoning process while ONCOCIN uses data-driven reasoning process. The main strength of ONCOCIN is that it allows an interaction with previous information or historical data but it requires inference rules based on assessment trends.

2.3 DIAVAL

DIAVAL is a medical expert system for the diagnosis of heart diseases and other kinds of data through echocardiography and other cardiac anomalies (7). In this system the diagnosis of a patient begins by registering

personal information, medical history and other physical examinations. The information is placed in a blackboard (stores facts supplied by both the user and the system that can help solve the problem). The inference engine scans some of the rules while looking for matching patterns based on the query provided by the user. All matching rules will be added to the blackboard for further assessments (7).

3. MEDICAL EXPERT SYSTEM IN RURAL AREAS

Expert systems can assist a human expert in rural areas during the problem solving process (4). They are very useful in places with high numbers of health sector difficulties such as Pakistan (4). Most of these systems are applied in medical diagnosis, medical consultation and medical trainings.

3.1.1 Diagnosis

These systems are very useful in places with poor living conditions as they can be integrated with multilingual speech recognition for patients who cannot read or write. Medical expert systems can help in medical diagnosis of patients (in hospitals), for minor diseases based on current conditions and the patient's historical data. They can act in the place of a human expert (9) when they are not readily available.

3.1.2 Consultation services

Medical expert systems can help to give advice to patients in rural areas; these systems can be applied for different people. For patients who cannot speak, for patient who cannot read or write, for patient who cannot see and so on, by providing speech-based and text-based applications.

3.1.3 Training

These systems can be very useful in places where there is a lack of educational facilities (1). Expert systems are also used in places where there is a shortage of doctors or other trained personnel (12) and to help teach students, for example, medical student. These systems are utilized to help solve livelihood problems and can improve the lives of rural communities. (13)

4. ARCHITECTURE OF AN EXPERT SYSTEM

The fundamental structure of an expert system consists of four modules: Working memory, knowledge base, inference engine and a user interface (4). Other expert systems also consist of: Knowledge-acquisition (a process of acquiring, organizing and studying knowledge), an explanation module and a blackboard (7) instead of having working memory.

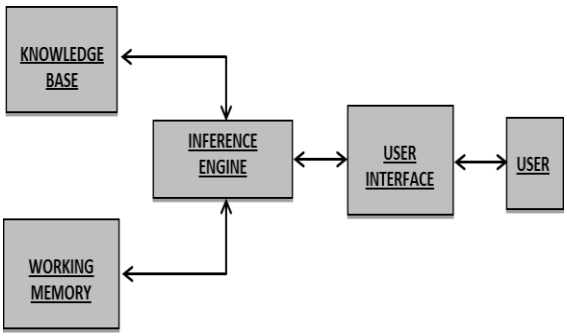

Figure 1: Structure of an expert system

Figure 1 above shows the structure of a medical expert system. Assuming the user interface acts as a physician or a patient, the user will answer a few questions about their conditions and the physician might need to add more medical data about a patient to help solve the problem.

4.1 The knowledge base

The knowledge base is the heart of the expert system (5). It is the collection of facts and rules which describe all the knowledge about problem domain (4). It takes a collection of relevant knowledge that is stored in a computer and organizes the information in such a way that it can be used for inferences. These inferences are generally in the form of

IF-THEN rules (5) that make use of various tests to rule in or out a diagnosis. These tests are scheduled based on suspicion of disease (14). Most of these systems are based on the concept of production rules (12), hence a rule is defined as "an IF-THEN" type structure which relates some known information contained in the "IF" part to other information. This information can then be concluded to be contained in the "THEN" part (4).

Example 1:
RULE 1:
IF Battery is dead
THEN Car will not start
RULE 2:
IF Battery voltage is below 10 volts
THEN Battery is dead

These two rules capture knowledge which represents natural relationships for automobile diagnostics. However, Rule 1 relates the status of the battery to the status of the car and Rule 2 relates the status of the battery to its own status. Each rule is a separate declarative statement about the problem, allowing one to add rules to the system (4).

4.2 The working Memory

Working memory is an input to the system which includes case facts about the user, such as medical history, current symptoms and inferred or answered questions (4). This information is used to evaluate antecedents in the knowledge base. A change in the knowledge base results in creation of new values and the update of old values in the working memory.

4.3 The inference Engine

An inference engine is a reasoning process of artificial intelligence or an analogy of human reasoning. Its role is to work with the available information from both the user and the system to derive new information or a solution to the problem (4). It can be presented in the form of a table with fields corresponding to the clinical condition findings (14).There are two principles of reasoning, namely: backward and forward chaining (4). In backward chaining one first establishes a hypothesis then attempts to prove it true. For an example, a physician may believe that a particular patient has a certain disease; he then collects information to verify this hypothesis. While in forward chaining one first collects information of the problem and then attempts to infer other information. For instance, a patient gives the physician information based on a particular disease and the physician gathers other information to prove this hypothesis. Both backward and forward chaining can be integrated to solve a given problem and this process is referred to as exact reasoning (4).

4.4 User Interface

The user interface is an intermediate that allows communication between the user and a computer. It takes input to the system such as symptoms or signs, and presents output to the user such as diagnosis results, a summary of case facts, recommendations or treatment details (4).

5. SUMMARY

Most medical expert systems are only available to diagnose one disease. The disadvantages with the use of rules are knowledge representation and uncertainty management are more likely to lead to erroneous conclusions (7). Most of these systems are designed to solve one domain (12). Other systems cover more domains such as web-based information systems for supporting physicians in the elaboration of a second opinion about medical cases (8).

6. CONCLUSION

The paper presents the use of medical expert systems and illustrates significant information such as its application areas. The idea is to use

an expert system to provide support and advice in common clinical conditions such as prediction of diseases, diagnosis of diseases etc. Such programs can be very useful in rural areas where there is a shortage of medical experts. The problem for creating these systems in rural areas is a lack of computer literacy. However more features can be added to these systems to allow people to physically interact with them via text or speech. This will create an advantage to blind people, handicapped people and other disabled people.

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