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A Brief Study of Medical Expert Systems

Mamta Tiwari, Prashant Srivastava
Department of Computer Application, University Institute of Engineering and Technology, C.S.J.M. University, Kanpur, India

ABSTRACT
Expert systems are used extensively in many domains. This paper discusses the use of medical expert systems. There are many applications of medical expert systems for predicting and diagnosing a particular disease. But medical expert systems are now also involved in many other roles in clinical care such as disease prevention, therapy, rehabilitation of the patient after therapy etc. The current paper develops taxonomy for the medical expert systems and briefly discusses three such expert systems.
Keywords : Expert Systems, Disease Prevention, Therapy, Rehabilitation

1. Introduction

Expert systems are intelligent computer programs designed to simulate the problem-solving behavior of a human being, who is an expert in a narrow domain or discipline.
There are many applications of expert systems ranging from agriculture, finance, education, medicine. Among all expert systems, the expert systems related to medicine need special mention. Medical expert systems are used for various medical tasks. Medical expert systems are also useful in certain situations where either the case is quite complex or there is no medical experts readily available for patients.
These expert systems are meant to be used by doctor as well as by other persons. In some situations, human experts are unable to give the correct solutions to the problems where expert advice is absent or expert is not able to give specific solution because of any deficiency of knowledge/information.
The medical expert systems are such an efforts to bridge the gap and remove the deficiencies. The expert system uses knowledge bases for answering the queries and giving expert advices. Data mining is such a technology which can be used to extract useful knowledge from huge databases [3]. Such IT based developments provide new opportunities to improve the utilization and performance of livelihood technologies such as agriculture, education, library, health and medical services. The research challenge here is to explore the areas where progress in IT could be used to improve the living standard of general population. Extracting knowledge from existing sources of information is a key development area to unlock yet unknown relationships between specific data point.
There are various expert systems in which a rule-base and an inference engine co-operate to simulate the reasoning process that a human expert pursues in analysing a problem and arriving at a conclusion. In these systems, in order to simulate the human reasoning process, a vast amount of knowledge needed to be stored in the knowledge base. Generally, the knowledge base of such an expert system consisted of a relatively large

number of “if then” type of statements that were interrelated in a manner that, resembled the sequence of mental steps that were involved in the human reasoning process.

An expert system can be defined as a piece of computer software that uses encoded knowledge to solve problems in a specific domain that normally requires human expertise. The current paper aims to provide a brief survey of the present trend rather than performing in-depth review and analysis of the technology. It discusses the design and implementation issues of medical expert systems. The paper also provides concise overviews of some medical expert systems for health protection that are being successfully used.

2. Design and implementation issues of a typical medical expert systems

Developing an expert system for health protection is not a trivial task. Several issues are required to be considered during the design and implementation stages. Some of these issues are quite different from the issues in developing expert systems in other domains [3]. The expert systems for health protection are meant to be used directly by the doctors and the public of all types. Although a formidable part of this clientele group may be computer literate, some of them may not be proficient computer users. The expert systems should be such that this class of users finds it easy to use. Another sensitive issue is the use of the local languages that will help the expert systems for health protection to spread to general public who is not very fluent in English all the time or well versed with medical terminology. The key issues for success of expert systems [2] for health protection have been Identified and listed below.

1. ***User friendly:*** The expert systems should be easy to use. They should not ask too many questions as that may overwhelm most users. The questions should be straight forward and their answers must be well defined.
2. ***Simple user interfaces:*** The user interfaces of the expert systems must be kept as simple as possible. The questions should be asked one by one and the expert systems should not display too much information at a time.
3. ***Use of photographs:*** The expert systems should use photographs of various deformed/ diseased organs and to help the users to correctly identify the symptoms as in case of mouth cancer or chicken-pox etc.
4. ***Use of interactive controls to avoid typing***. Since most users may not be Habituated to use computers, the expert System should use various interactive Controls like radio button, check box, Dropdown list and list box to minimize The need of typing.
5. ***Option for printouts:*** Option to print a copy of the diagnosis and the proposed treatment should be available for future reference and records.
6. ***Setup program:*** The expert systems must come with simple setup programs so that the users can themselves install the expert systems on their computers.
7. In addition to the direct web-based interface, the system should also provide an XML-based interface, allowing for the easy data exchange with doctors’ other software applications and other doctors world over.
8. Since privacy is the most sensitive issue so the system should obey the strictest privacy manners/laws. This requires in particular that data is collected with full consent of the patients and can only be used for the express purposes given in the consent statement; and patients retain the right to review their data and to have it removed at any time.

3. Tools for building expert system

Medical expert systems can be constructed either through Al languages or from expert systems shells. Expert system shells provide more general facilities and an easy way to enter necessary knowledge about the problem domain. ESTA, EXSYS, XpertRule, ACQUIRE, FLEX etc. are some of the popular Software packages used in the construction of medical expert systems. LISP and PROLOG are two famous Al languages used to develop medical expert systems.

Milord II is a programming language and a tool for the development of expert systems [5]. Milord II is a free prototype available for research purposes. The main goal of Milord II is the programming of real world expert systems, that is, those dealing with real problems and programmed by real experts. Programming in the large and imperfect information treatment is one of the most important characteristics of Milord II

4. Examples of medical expert systems

Four experimental systems are generally regarded as having started the research field of artificial intelligence in medicine. These were MYCIN, a program to advise physicians on antimicrobial selection for patients with bacteremia or meningitis; the Present Illness Program (PIP), a system that gathered data and generated hypotheses about disease processes in patients with renal disease; INTERNIST-1, a large system to assist with diagnosing complex problems in general internal medicine, and CASNET, an ophthalmology advisor designed to assess disease states and to recommend management for patients with glaucoma. All four drew on Al techniques, emphasizing the encoding of large amounts of specialized medical knowledge acquired from the clinical literature and from expert collaborators.

In addition to those written above there exists few more medical expert system namely Heart Disease Program (HDP) [1] and Pulmonary Function System (PUFF) [1].

A brief review of the above written two types of expert systems (HDP and PUFF) is given next, starting with the pioneer one, MYCIN [4].

5.1 MYCIN

MYCIN was the first well known medical expert system developed at Stanford University to help doctors, not expert in antimicrobial drugs, prescribes such drugs for blood infections. MYCIN has three sub-systems as given:

1. Consultation system
2. Explanation System
3. Rule Acquisition system

The doctors have to take care of various issues at different stages of treatment as in case of prescribing drugs for blood infections as whether the patient suffering from an infection? What's the organism? Which drugs are appropriate? (Some drugs are too toxic for safe use; whereas no single antibiotic is generally effective). Which one to select? etc.

There are also a lot of things that the doctor has to keep in mind when prescribing treatment as the possible type of microbe, age, weight and sex of patient, likely effectiveness of antimicrobial drugs, oral, intravenous, intramuscular administration of drugs, dosage etc.

Amidst all these complexities there are always a good number of chances of mistakes on the part of doctor as non- expert doctors don't go through this process or they prescribe habitual choice or they may over prescribe, that results in wastages of money, time degraded health condition and a lot more related problems which may become fatal some times.

Whereas in the case of MYCIN rules are stored as conjunctions and disjunctions of conditions, the conditions are normally evaluate to True or False, there is some degree of certainty factor exists.

Rules also have certainty factors and combine to form new certainty factors ic. Degree of belief attached to information. The actions are either conclusions (e.g. microbe is type X) or instruction (e.g. remove drug from list of possible)

MYCIN first attempts to create patient record containing information about the case, and then tries to compile a list of therapies for the patient.

It uses a backward chaining mechanism, reasoning back from the goals it wants to prove to the data it has, rather than vice versa. The overall goal is to compile a list of therapies.

MYCIN can answer questions about how a conclusion was reached or why a question was asked, either after a consultation or while it is going on. It does this by manipulating its record of the rules it invoked, the goal it was trying to achieve and the information it was trying to discover.

Experts can enter new rules or edit existing rules. The system automatically adds the new rules.

In typical run and testing of MYCIN it was found that the software is more accurate and efficient that the senior contemporary doctors.

5.2 HDP

The Heart Disease Program (HDP) is a large diagnostic program covering most areas of heart disease. The physician can enter patient information about the history, physical examination, and laboratory tests, and then the program generates detailed explanations of differential diagnoses indicating the clinical data items which support each diagnosis. Its purpose is to assist doctors in the diagnosis of patients with heart disease. The Heart Disease Program (HDP) can be divided into 3 main components:

1. A user interface,
2. The knowledge base and inference mechanisms,
3. Mechanisms to summarize and explain diagnoses.

Knowledge acquisition is the most important aspect of the expert system development. It is referred to as the process of transfer and transformation of expertise from knowledge sources to a program. HDP gets knowledge from cardiologists and from books, also it develops the knowledge base from clinical expertise incrementally by adding proved cases (After the diagnosis had been done by HDP the cardiologists were asked to comment on which diagnostic elements were most relevant, which were not relevant, and what was missing to update knowledge base).

Knowledge must be modeled or represented in a way that a computer can process. The model of knowledge used by expert system is called knowledge base. The knowledge base of first version of HDP was rule based; a program has large number of interconnected and nested IF-THEN statements, or rules, that are the basis for knowledge in the system. However, it soon became apparent that uncertainty plays large part in the diagnosis

and management of heart disease that the program had to deal with probabilities directly. For this reason, the knowledge base of second version of HDP is implemented as a network of 200 nodes, analogous to a Bayesian belief network, representing common potential heart diseases. The nodes are linked by probabilities; the probability on the link may be fixed or dependent on patient data. However, nodes in the HDP can represent different severity levels of diseases, and feedback loops are permitted. Mechanisms to reason about the time course of symptoms and diseases are incorporated. HDP being a web based diagnostics system that is always available all over the globe, so it spreads the expert knowledge of a few highly skilled advanced doctors and leading experts in their fields to a much broader medical community.

5.3 PUFF

Puff expert system diagnoses the results of pulmonary function tests. Its task is to interpret a set of pulmonary function (PF) test results, like volume of the lungs, the ability of the patient to move air into and out of the lungs, and the ability of the lungs to get oxygen into the blood and carbon dioxide out, then it produces a set of interpretation statements and a diagnosis for the patient. Its purpose is to generate reports from a set of interpretation statements for pulmonary function diagnosis. The pulmonary function expert posed hypothetical rules for diagnosing the illness and the knowledge engineer encoded the rules (in LISP) and tested them with the test cases. The expert reviewed the test results and modified or added rules to handle the cases that were incorrectly diagnosed. It continued until the expert system was satisfied.

The knowledge base of PUFF was rule based; consists of a set of 64 production rules dealing with the interpretation of pulmonary function tests (A more recent version had about 400 rules).

Many medical expert systems had required large amounts of time for data input, PUFF produced PF interpretations automatically without the necessity for user interaction. The data needed to interpret patient status are available in a computer from the patient's history and from measurements taken in a laboratory. Other information is not required in order to produce accurate diagnoses of pulmonary disease in the patient.

The amount of domain-specific knowledge involved in pulmonary function testing is limited enough to make it feasible to acquire, understand, and represent that knowledge. PUFF system is very easy to use.

6. Summary and Future Scope

In present scenario various expert systems pertaining to the medical domain are in business. Despite tremendous growth and planning in every walk of life, India is still in grip of poverty, poor health services etc which makes every progress meaningless. AIDS, Yellow Fever, Hepatitis are just a few names. If some intelligent expert system would come into existence in Every now and then, we get the news of spurt of epidemics. Malaria, Dengue, future which deals with such problems also, that would be a great help to mankind and humanity as a whole.

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