A New Expert System for Pediatric Respiratory Diseases by Using Neural Networks

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Abstract- The successful application of data mining in highly visible fields like e-business and marketing have led to the popularity of its use in knowledge discovery in databases (KDD) in other industries and sectors. Among these sectors that are just discovering data mining are the fields of medicine and public health. The medical industries collect huge amounts of healthcare data which, unfortunately, are not “mined” to discover hidden information. We can describe this data as being ‘information rich’ yet ‘knowledge poor’. In this study, we briefly examine the use of the most important data mining techniques such as Artificial Neural Network to massive volume of data in medical field which is pediatric respiratory disease. Using medical symptoms such as dry cough, productive cough, fever, heamoptysis, tachypnea, dysnea and etc. Also using doctor sign such as bronchial breathing, chest pain, clubbing of finger, crepitation, ronchi, cyanosis, decrease breathing sound on auscultation, dullness on percussion, hyper resonant on percussion, inability to swallow, mucopurelent sputum, pleural rub, respiratory distress, sputum (white), stridor, upper respiratory infection, wheezing, X-ray [showing lung consolidation], X-ray [shaving edematous epiglottic], X-ray [showing subglottic narrowing and classic narrow trachea], X-ray [showing hantanslucent lung], X-ray [showing lobar collapse and (increase) bronchovascular marking], X-ray [showing diffuse haziness], it can predict the likelihood of patients getting a respiratory disease. They enable significant knowledge, e.g. patterns, relationships between medical factors related to respiratory disease, to be established.

Keywords - Data mining, artificial neural network, medical application respiratory diseases.

1. Introduction

Data mining and its application to medicine and public health is a relatively young field of study. In 2003, Wilson et al. began to scan cases where KDD and data mining techniques were applied in health databases. They found confusion regarding what constituted data mining. “Some authors refer to data mining as the process of acquiring information, whereas others refer to data mining as utilization of statistical techniques within the knowledge discovery process.” [1]. Despite the differences and clashes in approaches, the health sector has more need for data mining today. There are several arguments that could be advanced to support the use of data mining in the health sector, covering not just concerns of public health but also the private health sector (which, in fact, as can be shown later, are also stakeholders in public health) [2]. Because of misconceptions still going on in the medical community about what data mining comprises, let us first define what we mean by it. The generally accepted definition of data mining today is the set of procedures and techniques for discovering and describing patterns and trends in data [3].

In fact, some experts believe that medical breakthroughs have slowed down, attributing this to the prohibitive scale and complexity of present-day medical information. Computers and data mining are best-suited for this purpose [4]. Data Mining is the discovery of unknown information found in databases [5] [6]. Its functions include clustering, classification, prediction, and associations. One of the most important data mining applications is that of mining association rules which, first introduced in 1993 [7], that used to identify relationships among a set of items in databases [8]. Respiratory disease databases are elements of our research. This database consists of 699 case and this cases have many common symptom such as dry cough, productive dry cough, productive cough, fever, heamoptysis, tachypnea, dysnea and etc. this symptom are common in eight disease as bronchiolitis, pneumonia, acute epiglottitis, pleurisy, emphysema, acute laryngotracheobronchitis, bronchial asthma and bronchiectasis.

The rest of the paper is organized as follows. Medical expert system used in this paper is described in Section 2. Architecture of a typical expert system is detailed introduced in Section 2.1. In Section 2.2 the design of medical expert systems is presented. In Section 3, review of medical expert system in respiratory system is examined. Design of expert system by using artificial neural network and conclusion are presented in Section 4 and Section 5, respectively.

2. Medical expert system

Medical expert systems for diagnosis, treatment and management of diseases are gaining importance in the
practice of modern medicine. Expert system is a program which uses artificial intelligence to provide solutions to difficult questions requiring specialized training to answer. Decision making in Intensive Care Unit (ICU), analysis of practice of respiratory medicine which will benefit from an unbiased guidance. Artificial neural networks, object oriented framework, fuzzy logic, genetic algorithm are some of the recent techniques used for the development of faster, efficient and reliable medical expert systems [14]. Recent years have witnessed an exponential increase in the application of computers in the medical field. Application of computers in biomedical engineering provides unparalleled opportunities to explore newer strategies for prevention, early diagnosis and specific therapy for large number of medical needs. Analyzing the recent developments in medical computer science, it is clear that the trend is to develop new methods for computer aided decision making in medicine to evaluate critically the methods in clinical practice.

Development of expert systems in medical field has already emerged as a major area in the application of computers in medicine [15]. Despite some promising examples of the use of expert system to enhance patient care, very few products are routinely used in clinical setting [16]. One of the important factors that have limited the acceptance of decision making support tools for clinicians is the lack of medical staff involvement in the system development [17]. Expert system is a program to provide solutions to difficult questions requiring specialized training to answer. In an expert system, comparison, classification and identification are essential requirements. Providing all possible symptoms and corresponding disease conditions in a computer through programs it can make a sufficiently sound solution to a particular problem, perhaps as good as the case an expert doctor would have made in that context, based on his intelligence, experience and knowledge. But here accuracy of diagnosis depends on the domain expert's doctor contribution and knowledge engineer's skill in the development of the system [18]. When a computer is independently involving in any type of decision making or computing activity, it is said that activity is automated. The biggest single use of Artificial Intelligence (AI) technique today is in expert system. Expert system is designed using AI technique to operate in a real-world domain. The goal is to develop a system which can make expert level judgments and recommendations in the field. In most of the cases it is a rule based. Artificial intelligence application program provides expert quality solutions to problems in a specific domain. Its knowledge is extracted from human experts in the domain and encoded in a formal language and it attempts to emulate their methodology and performance. They are open to inspection, modification and analysis [18].

2.1 Architecture of a typical expert System

The expertise comes from education, experience, intelligence and intuition. The effective and efficient integration of the above qualities make the decision making process more meaningful figure (1).

![Decision-making process](image)

Expert systems can be either rule based or frame based. The various functional blocks of a typical expert system are user interface, explanation subsystem, knowledge base editor, case specific data, general knowledge base and inference engine [19, 20] figure (2).

![Architecture of a typical expert system](image)

**User Interface:**
This is for the interaction between the user and expert system.

**The explanation subsystem:**
This allows the program to explain its reasoning to the user. The explanation includes justification for the system's conclusions.

**Knowledge base editor:**
It is to locate bugs in the program's performance, to assist in the addition of new knowledge, to help maintain correct rule syntax and perform consistency checks on the updated knowledge base.

**Case-specific data:**
The program must track case specific, the facts, conclusions and other relevant information of the case under consideration.

**The general Knowledge base:**
The heart of the expert system is the general knowledge base, which contains the problem solving knowledge of the particular application. It should be knowledge rich.
Inference engine:

This is a computer term given to that part of the program (software) which applies mainly to the solution of actual problems. It is the interpreter for the knowledge base.

Rule based representation:

The use of if then rules (also called production rules or condition-action pairs) is a straightforward popular way to represent the expert know how. The type of knowledge is often said to be shallow. Given a set of facts, the reasoning process is then modeled as the successive activation of rules, which in turn produce new facts to be considered, until no applicable rule can be found.

Frame based representation:

Frame-based representations have been introduced as a way to organize prototypical knowledge about the world. A frame defines the prototypical description of concepts sharing similar properties and behavior. It is defined as a set of slots describing the concept attributes and their rules. The personnel involved in the development of an expert system are the domain expert, the knowledge engineer, and the end user.

2.2 Design of medical expert systems

The vast amount of existing medical knowledge and the rapid growth of that knowledge have resulted in a situation where most physicians find it increasingly difficult to assimilate all the information which would be useful in making optimal clinical judgments, even after specialization. It is not surprising that empirical studies have demonstrated that physicians do not always make optimal decisions [21]. Now it has been approved by all concerned that computer assisted medical decision making system, medical expert system, might provide a solution to the problems in diagnosis and patient management. Such systems are generally intended to support and not replace physicians, complementing their natural abilities to make judgments with the computer's memory, reliability and processing capabilities [22]. Medical expert system has evolved from computer science through artificial intelligence figure (3).

They are based on symbolic models of disease entities and their relationships to patient factors and clinical manifestations. Diagnostic expert systems help the doctors to determine the range of alternative diagnosis or a definitive diagnosis systems used for treatment helps in deciding on an action plan where multiple options are available in individual cases. Quick decision making in differential diagnosis and selection of proper treatment in a short time are the features of the medical expert system [23-25].

3. Review of medical expert system in respiratory system

In respiratory system, as well as in other field of medicine, the differentiation between normal and abnormal is difficult. Reason is that there are no two subjects exactly alike because every biological quantity is a variable influenced by heredity, environment, occupation, nutrition, age, sex, culture etc. Hence even in perfectly normal subjects most biological quantities are scattered over certain range of values [26]. These facts should be well taken care of during the development of medical expert systems for respiratory system diagnosis. It reveals the requirement of the close association of the domain expert and the knowledge engineer. The scope of developing a wide variety of medical Expert Systems in Respiratory medicine is unlimited. The complex jargon of respiratory physiology and mechanics have made pulmonary function tests very unpopular among general practitioners. The decision making in intensive care units for mechanically ventilated becomes challenging even to specialists because of the complex ventilator mechanics. The evaluation of unexplained breathlessness or assessment of respiratory function in sportsmen is not an easy task. Thus creating a stable, popular, power full and user friendly program can help the physician in many ways.

Chronic diseases like asthma, chronic obstructive pulmonary diseases, interstitial lung diseases and tuberculosis can be managed better if suitable algorithms are created and a set of treatment choices are outlined. This then becomes useful in managing a large group of patients in busy hospitals. Decision making in individual cases also
will be made easy then. There is only a limited number of medical expert systems available in this area. Even though the development of medical expert systems started right from the mid 1970s with the development MYCIN [27], the number of articles in computer aided medical diagnosis up to 1979 was only two [28]. Mycin was developed to assist in the treatment of infectious diseases in particular bacterial infections in the blood. In this, in addition to the performance program, there are three adjunct programs that increase system utility and flexibility. After this period, development of some medical expert systems in the area of respiratory system has taken place [29-36] (Table 1). On close observation, it can be seen that each of them are more or less concentrating on very narrow specific areas of respiratory system. Note of the expert systems developed can analyze respiratory system as a whole.

Artificial neural network is another artificial intelligence (AI) tool now in use for the development of expert systems. It consists of numerous, simple processing units or neurons that we can globally program for computation. We can program or train neural networks to store, recognize and associatively retrieve patterns or data base entries and to solve different types of optimization problems, i.e., to estimate sampled functions when we do not know the form of the functions. The overall network behaves as an adaptive function estimator. It has been used successfully in many different applications [37-122]

### Table 1. Medical Expert System in Respiratory System

<table>
<thead>
<tr>
<th>Expert System</th>
<th>Purpose</th>
<th>Comments</th>
</tr>
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<tbody>
<tr>
<td>APACHE11 Ref(29)</td>
<td>To help to estimate patient mortality, length of stay and artificial ventilation.</td>
<td>It is for a larger patient management system for use in the ICU.</td>
</tr>
<tr>
<td>CAPNEX Ref(30)</td>
<td>To help to perform patient medical diagnosis and instrument fault detection.</td>
<td>It is based on clinical capnography data and experience.</td>
</tr>
<tr>
<td>CENTAUR Ref(32)</td>
<td>To overcome some of the problems PUFF could not handle well.</td>
<td>It is a rule based pulmonary function analysis system.</td>
</tr>
<tr>
<td>GUIDON Ref(31)</td>
<td>To teach facts and problem solving strategies related to pulmonary function analysis.</td>
<td>It uses the knowledge base for MYCIN. It is only a tutor package.</td>
</tr>
<tr>
<td>PUFF Ref(32)</td>
<td>Developed for the task of pulmonary function tests.</td>
<td>It used standard pulmonary function tests and laboratory measurements for diagnosis.</td>
</tr>
<tr>
<td>RESPAID Ref(33)</td>
<td>To support interpretation of respiratory data for ventilated patient.</td>
<td>It has been developed in order to acquire automatic collection of data from standard monitors and/ or respirators.</td>
</tr>
<tr>
<td>VENTEX Ref(34)</td>
<td>To support decision making in the management of</td>
<td>The system is intended to be used in the case of patients with respiratory failure.</td>
</tr>
</tbody>
</table>

### 4. Design of expert system by using artificial neural network

Imagine the way the human mind works when presented with a problem. At first, the problem’s facts are analyzed and weighted at some sensorial level. Next, these facts are passed through neural paths, which act as filters and are based on previously known patterns. This leads to conclusions, which may be possible solutions to the problem or may serve as additional facts for a new iteration over the neural paths [13]. Artificial Neural Networks (ANNs) have been extensively used in many research areas from marketing to medicine [9]. They first received much attention from computer scientists, neurophysiologists, psychologists, and engineers, interested in biological nervous system organization and artificial intelligence. Their two main applications in medicine are pattern recognition (classification) and prediction: during these last years (from 1990s and increasing in the 2000s), the applications for prognostic and diagnostic classification in medicine have attracted growing interest in the medical literature [10].

Building Neural Networks (ANNs) have been applied in a wide range of problems and have given, in many cases, superior results to standard statistical models [11]. In particular, the predictive reliability of ANN models has been demonstrated in medical diagnosis [12].

Neural networks are pattern-learning instruments that are more sophisticated than decision trees and Naïve Bayes. Figure (4) shows a couple of examples. A neural network contains a set of nodes (neurons) and edges that form a network. There are three types of nodes: input, hidden, and output. Each edge links two nodes with an associated weight. The direction of an edge represents the data flow during the prediction process. Each node is a unit of processing.
Input nodes form the first layer of the network. In most neural networks, each input node is mapped to one input attribute (such as productive cough, stridor, or fever). Hidden nodes are the nodes in the intermediate layers. A hidden node receives input from nodes in the input layers or precedent hidden layer. It combines all the input based on the weight of associated edges, processes some calculations, and emits a result value of the processing to the subsequent layer. Output nodes usually represent the predictable attributes. A neural network may have multiple output attributes, combining several output nodes in the same network reduces the processing time because such networks can share the common cost of scanning the source data. The result of the output node is often a floating number between 0 and 1 [13].

In our medical application input nodes represent the symptoms of the eight cases of respiratory disease. Such as dry cough, productive cough, fever, heamoptysis, tachypnea, chest pain, dysnea and etc. also using medical sign such as bronchial breathing, cyanosis, dullness on percussion, hyper resonant on percussion, pleural rub, respiratory distress, wheezing and et al. In addition to some medical investigation as X-ray showing lung consolidation, X-ray showing edematous epiglottic, X-ray showing subglottic narrowing and classic narrow trachea, X-ray showing diffuse haziness. The output nodes represent eight cases of respiratory disease. As we see in our study that the output value is a floating number between 0 and 1.

This means that our result is as the previous concept. And the original value of an input attribute must be massaged to a floating number in the same scale (often between -1 and 1) before processing [13].

Use the input vector data set. This data set consists of 699 Twenty-seven-element input vectors and eight-element target vectors. Input vector contain 699 cases with some common symptoms and different in some symptoms. The results of examination for these cases are described in figure (6).

We use MATLAB source and train the network with the input vector and the target vector as described in figure (7).
We can see that the mean Square Error is correct of the trained data, validation data, and test data, all take the same curve. This means that the network learns from cases and this depends on the amount of the input cases. If the input cases are large then the output cases in test cases is extremely correct.

After we train network with input and target vectors now we test the network by enter twenty cases to the network.
with out the target vector. And let the network to give us the right examination that is one of eight cases.

Figure (13): data used in testing the network

As we see in figure (14) the result of test data. The first column indicate that the first value in column is 0.8130 ≈ 1 and all values follow it ≈ to zero this mean that the patient examination is pneumonia and so on.

Figure (14): examination result of the test data

5. DISCUSSION

In the presented study we have trained the network with large amount of data and we see that as we train the network, the network can give correct decision about the correct examination to the entered symptoms. As we know that our study is about pediatric respiratory disease. Artificial neural networks also learns after it faces 699 cases with different symptoms. The computer program was performed under MATLAB software using the neural network toolbox. In the training, the number of neurons on the hidden layer is 20. A dataset including 699 data samples obtained from experimental studies were used for ANNs. From these, 699 data patterns were used for training the network, and the remaining 20% patterns were randomly selected and used as the test dataset. The results are shown in Figs.5-14. After training the network we test it with some different cases with out the target output vector and the network gives us the correct diagnosis. So the artificial neural network is very useful data mining technique for recognition of pediatric respiratory disease.

References


