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REVIEW OF A MEDICAL PREDICTIVE SYSTEM FOR MEDICAL ANALYSIS

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Abstract:
Health has a strong impact upon all activities and human experts must have the ability to decide, in any circumstances, what is the illness level of a patient, which is the adequate treatment and which will be the evolution of the patient during the treatment. But medical decision making may be a very difficult activity. There are a lot of applications in artificial intelligence domain that try to help human experts offering solutions for a problem. This paper describes an expert system developed in order to make some predictions regarding health issues

Keywords: expert system, logical inference, statistical inference, artificial neural networks

Introduction

Medical domain is characterized, like many other domains, by an exponential evolution of the knowledge. There are a lot of tools which try to reduce the risk of error apparition in medical life. Diagnosis has a very important role here. It is the first step from a set of therapeutic actions; an error at this level can have dramatic consequences.

The presence of technology in diagnosis phase is welcome because of its advantages: pragmatism, repeatability, efficiency, immunity toward perturbation factors that are specific to human beings (fatigue, stress, diminished attention). The technology doesn't replace human experts in this point of medical assistance; it only tries to help them, implementing systems that are able to select or to generate data which are relevant for the physicians.

The system presented here belongs to this context. It is made using the main two branches of artificial intelligence:

— The traditional one, represented by expert systems (based on logical and statistical inference);

— The connexionist one, where the most common forms used are artificial neural networks.

Methods

A Expert Systems

There are two main possibilities of implementing expert systems: by logical inference and by statistical inference. Both of them were used in this system, in order to make some predictions regarding the hepatitis diagnosis and the evolution of an infected patient.

Logical Inference

The logical inference could be used in medicine to build expert systems that will produce a diagnosis starting from a set of premises. An expert system implements human reasoning and it needs some rules to make it possible. This type of system is also called rules based expert system and it is the most used system for implementing medical diagnosis [2]. It has a graph structure and a chain logical evaluation is applied on this structure. Such an expert system could be easy to implement and also very easy to use for a non-engineer because its rules are similarly with the natural medical language.

This type of expert system is easy to be implemented for simple rules like 'logical premises → conclusion', but it is not suitable to use logical inference for huge amounts of connected knowledge because the graph becomes too complex. Frequently, it is hard to express the rules for the system and also the translation of implicit knowledge into explicit rules would lead to loss and distortion of information content [3]. On the other hand, the tree structure of rule-based relationships becomes too complex if new levels of knowledge are added. For example, there are many types of hepatitis B and if the system described before has to decide between these types, it will be difficult to implement it.

Statistical Inference

The statistical inference is an alternative to logical inference and offers a lot of methods that use information of a sample, to learn about population characteristics and to provide some conclusions or decisions. A problem that must be taken into consideration is linked to the fact that inferences are done based on the information contained in a sample, which is only a part of the whole population. From this point of view it is necessary to indicate the precision of the results. The probability plays an important role, being used to define the quality of an affirmation, to measure the uncertainty or to describe the chance for an event to happen.

In this area, the most frequently used method is the *Bayes's theorem*, which sets a probabilistic value for each considered output (disease, if the system is applied in medical diagnosis). Bayesian networks have an important area of applicability in the entire field of artificial intelligence, setting a posterior probability when prior probability is known [4].

Bayes's theorem suggests that probabilities can be improved with new information (Fig. 1). The analysis starts with the prior probabilities (preceding the experience) for the interesting events. Then it is used a supplementary information from a sample, a test, a report or from other sources, information that affects the probability of the events. The prior probability will be revised using this new information and the result will be the posterior probability (after the experience and based on the experience). Bayes's theorem is an easy way to find the posterior probability.

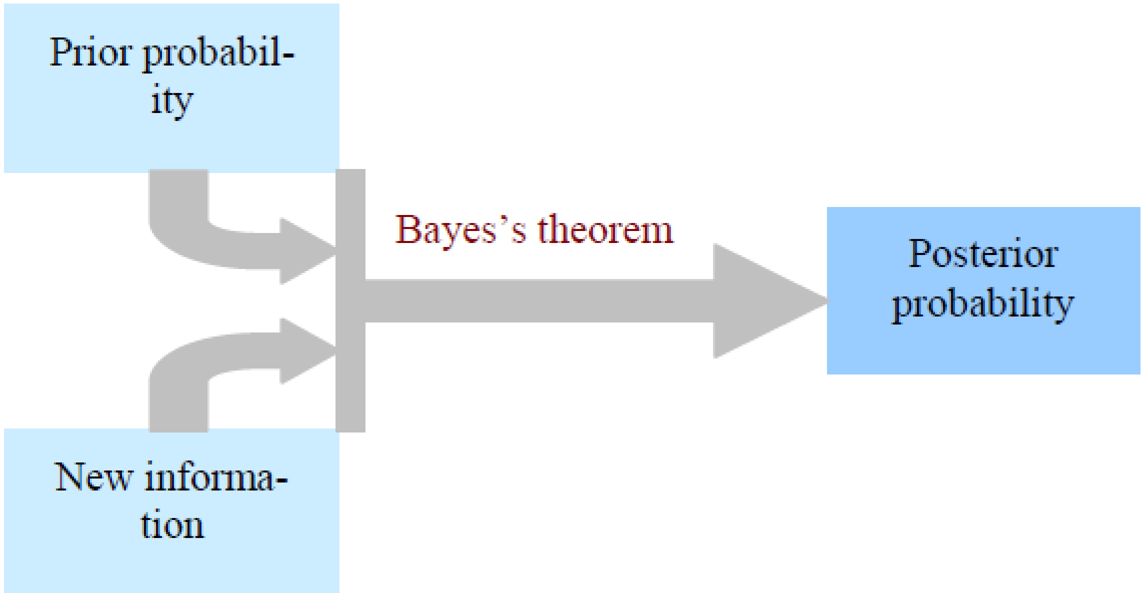

Figure 1 Bayes's theorem

Artificial Neural Networks

There are a lot of cases when is not possible to implement human intelligence with expert systems. This is the reason why artificial neural networks have been developed. The initial idea was that in order to reproduce human intelligence, it would be necessary to build systems with a similar architecture [6].

Artificial neural networks are developed based on brain structure, representing a simplified mathematical model of central nervous system. Like the brain, artificial neural networks can recognize patterns, manage data, and, most important, learn [7]. They are made by artificial neurons, which implement the essence of biological neuron.

In this system, artificial neural networks are used in order to make some predictions regarding the treatment response for a patient infected with virus.

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The system offers for each evaluated biological indicator predictions regarding the next 12 months evolution, indicating its growing tendency, its stabilizing or decreasing tendency. It was developed using feed-forward neural networks with back-propagation learning algorithm. Its architecture is in fact a network of neural networks. Each neural network has a layer of 10 hidden neurons, a single output unit and a variable number of inputs.

For each of the four biological indicators that have been studied, there are four layers of neural networks. The networks on the first layer receive as inputs: patient's age, sex, location (rural/urban), treatment scheme, Knodell score, hepatic fibrosis score and value of the parameter for which the prediction is made, at the initial moment (before the treatment starts). These

networks have as output the value of the biological parameter at 3 months. On the following layers the networks have the same structure as the first layer ones, but they have in addition, as inputs, the outputs of the networks on the former layers; therefore, the networks on the last layer will have not 7 inputs (as the networks on the first layer) but 10 (the initial inputs and the values of biological indicators at 3, 6, and 9 months).
The advantage of this architecture is that the input data are processed separate for each biological indicator. The disadvantage is that the errors are propagated through the system because the results of the networks from the first level (together with their errors) are used in the following levels. But this disadvantage can be minimized by learning process.

The Expert System

The application has a complex structure, analyzing information connected to the apparition of the hepatitis infection, its evolution, the antecedents, the symptoms, the results of the laboratory tests, and the evolution of some specific biological indicators during the treatment. It develops a multifunctional database and implements an expert system used in order to diagnose of sickness and to realize some predictions regarding the evolution of the patient and the response to the treatment. The system uses two major components (an inference machine and an architecture of neural networks) that operate on the multifunctional database (Fig. 2). It has an interdisciplinary character and fulfils the requirements of a system used in medical diagnosis and prediction

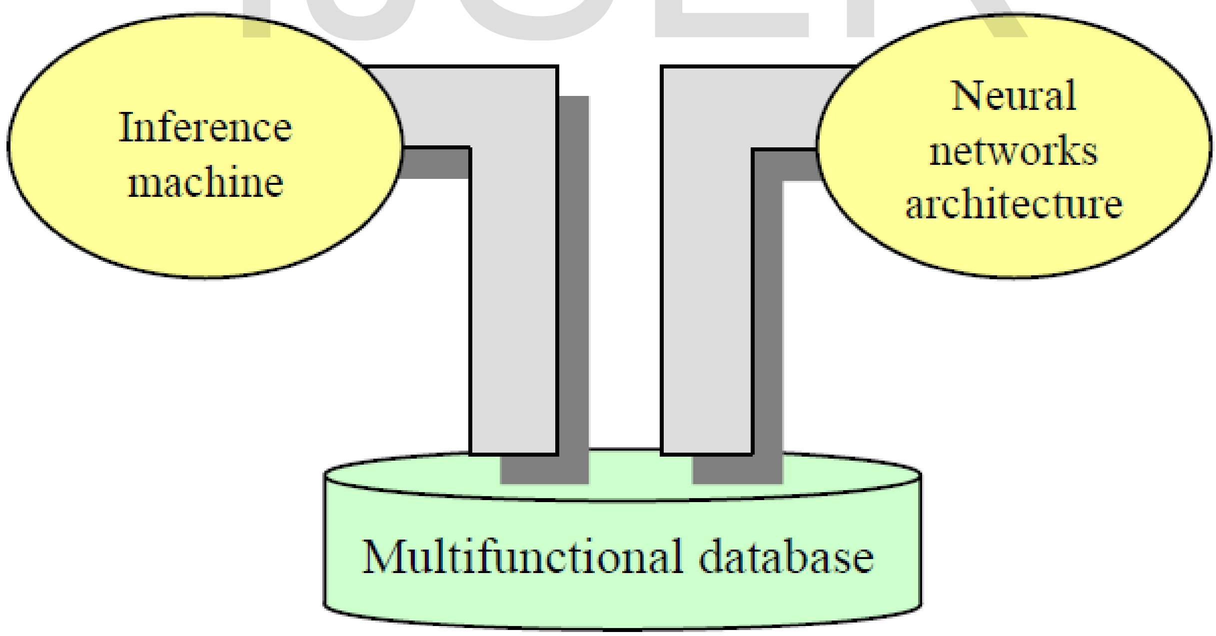

Figure 2: The configuration of the expert system

Conclusions

This paper tried to evidence some important aspects connected to medical decision making. Therefore, the system presented here is made from three important parts. First of all, logical inference is used. This branch of the system is developed using methods from statistical inference. The third part of the system is to predicts the biological parameters evolution during the treatment using artificial neural networks. Therefore, it is important to set a correct diagnosis and to identify those patients who most probably can react to the treatment, so that the others can be protected from a treatment with no benefits. That's for what the use of such a system can support the physicians' decisions.

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