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An Intuition Based Fuzzy Logic Driven Approach for Designing Symptomatic Medical Diagnostic Expert System

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***Abstract*— This paper explores an intuition based Fuzzy Logic driven approach for designing symptomatic Medical Diagnostic Expert system with an illustrative example.**

Keywords*— *Artificial Intelligence, Fuzzy Logic, Medical Expert System.

I. INTRODUCTION

The advancement in computer technology has empowered both software developers and domain knowledge experts to collaborate together towards building more intelligent tools for assisting domain-knowledge-practitioners in making their decisions. Of late quite a few machine-learning based techniques have emerged as promising tools for making automated decisions. With the maturity and acceptability of machine learning approaches over the years there has always been an emerging demand to develop techniques in artificial intelligence that can support fast, reliable and accurate medical diagnosis even with limited and vague information. The information available for searching this domain knowledge for a specific diagnosis is also usually vague and observations are incomplete and inaccurate due to the stochastic nature of mind/body psychology/physiology. In this paper, we have explored an intuition based Fuzzy Logic driven approach for designing symptomatic Medical Diagnostic Expert system.

A. Background Knowledge and Related Survey

The application of artificial intelligence (AI) techniques to medical problems has been a goal of computing since the development of high-speed digital computers. In the 1970s, medical artificial intelligence was responsible for the highly successful MYCIN program, the very first expert system [1]. In the 1980s, the rapid proliferation of AI technology, combined with the greater availability of computers in the medical environment, led to an increasing number of medical expert systems, such as PUFF, CADUCEUS and INTERNIST [2]. As in the business world, expert systems in medicine validated themselves when compared against human "experts" [3]. Most of human reasoning involves the use of variables whose values are fuzzy sets. This is the basis for the concept of a linguistic variable, that is, a variable whose values are words rather than numbers. Intuition based fuzzy sets as a generalization of fuzzy sets can be useful in situations when description of a problem by a fuzzy linguistic variable, given in terms of a membership function only, seems too rough [3]. For example, in decision making problems, particularly in the case of medical diagnosis there is a fair chance of the existence of a non-null hesitation part at each moment of evaluation. This uncertainty in decision making has motivated us to explore intuitionistic fuzzy sets as a tool for reasoning in the presence of imperfect facts and imprecise knowledge. An example of medical diagnosis has been presented assuming there is a database, i.e. description of a set of symptoms S, and a set of diagnoses D.

II. MEDICAL EXPERT SYSTEMS

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. 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. 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. 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 the accuracy of diagnosis depends on domain expert's contribution and knowledge engineer's skill in the development of the system. Therefore such systems are always open to inspection, modification and analysis. In subsequent sections, some of the well-known machine learning strategies are discussed with reference to expert system development.

A. Baye's Probabilistic Expert System

Bayesian networks are nowadays well established as a modeling tool for expert systems in domains with uncertainty [2]. Reasons are their powerful but conceptual transparent representation for probabilistic models in terms of a network. Their graphical representation, showing the conditional independencies between variables, is easy to understand for humans. On the other hand, since a Bayesian network uniquely defines a joint probability model, inference — drawing conclusions based on observations. Probabilistic inference is the problem of computing the posterior probabilities of unobserved model variables given the observations of other model variables. For instance in a model for medical diagnoses, given that the patient has complaints x and y, what is the probability that he/she has disease z? Inference in a probabilistic model involve summations or integrals over possible states in the model. In a realistic application the number of states to sum over can be very large. In the medical example, the sum is typically over all combinations of unobserved factors that could influence the disease probability, such as different patient conditions, risk factors, but also alternative explanations for the complaints, etc.

B. Fuzzy Based Intutionistic Expert System

Any history of fuzzy knowledge-based systems in medicine must take the development of the fuzzy set theory into account. This important branch of mathematics originated in the second half of the 20th century (1960's). Zadeh [9], a professor of electrical engineering at the University of California, Berkeley, defined fuzzy sets by their characteristic function (membership function), which is allowed to assume any value in the interval [0,1]. The space of all fuzzy sets in a given set becomes a Boolean algebra; thus, a propositional logic with fuzzy concepts constitutes fuzzy logic. Intuitionistic fuzzy sets as a generalization of fuzzy sets can be useful in situations when description of a problem by a (fuzzy) linguistic variable, given in terms of a membership function only, seems too rough. For example, in decision making problems, particularly in the case of medical diagnosis there is a fair chance of the existence of a non-null hesitation part at each moment of evaluation of an unknown object. To be more precise - intuitionistic fuzzy sets let us express e.g., the fact that the temperature of a patient changes, and other symptoms are not quite clear. By following the reasoning of De, Biswas and Roy [4] (which is an extension of Sanchez's approach [5, 6]), we will now consecutively recall their approach to medical diagnosis via intuitionistic fuzzy sets, or to be more precise via intuitionistic fuzzy relations that in effect boils down to applying the max-min-max composition [3].

C. Illutrative Example of Intutionistic Fuzzy Inference

This section illustrates intuitionistic fuzzy inferential strategy with a simple medical case. It is well known fact that the body temperature for diseases like Malaria (M) and Viral Fever (VF) acts as a viable symptomatic option to the medical practitioner. In order to apply fuzzy inferential strategy, let us grade the severity of temperature as Critical (C), Very High (VH), High (H), Average (AV), Low (L), and Very Low (VL).

Table 1 and Table 2 indicate the perceived temperature severity in terms of fuzzy degree with regards to Malaria (M) and Viral Fever (VF) respectively.

R1	C	VH	H	AV	L	VL
M	1.0	1.0	1.0	0.2	0	0

Table 1 Fuzzy Temperature for Malaria

R2	C	VH	H	AV	L	VL
VF	0.6	0.8	1.0	0.2	0.1	0

Table 2 Fuzzy Temperature for Viral Fever

Doctor	Doctor 1	Doctor 2	Doctor 3
Patient	C	VH	H

Table 3 Doctor's Perception on Body Temperature

A patient with high body temperature consults three doctors for diagnosis. Following table represents the degree of temperature perception of individual doctor relative to fuzzy temperature scale.

Doc/Temp	C	VH	H	AV	L	VL
D1→C	1.0	0.8	0.6	0.2	0.0	0.0
D2→VH	0.8	1.0	0.6	0.2	0.1	0.0
D3 →H	0.6	0.8	1.0	0.4	0.2	0.0
MIN	0.6	0.8	0.6	0.2	0.1	0.0

Table 4 Doctor's Fuzzy Level Temperature Scale

The intuitionistic Hamming Distance for Malaria:
1/6{|0.6-1.0| + |0.8-1.0| + |0.6-1.0| + |0.2-0.2| + |0.1-0.0| + |0.0 – 0.0|} = 0.183
and the same for Viral Fever:
1/6{|0.6-0.6| + |0.8 – 0.8| + |0.6 –1.0| + |0.2-0.2| + |0.1-0.1| + |0.0-0.0|} = 0.067
Since the hamming distance of Viral Fever is lesser compared to Malaria, it can be concluded that the Patient has more chances of contracting Viral fever.

III. CONCLUSION

In this paper, we have explored viability of a concept called Intuitionistic Fuzzy inference and discussed its working principle. In the proposed method, we measured the chance of each probable disease by considering the symptoms of that particular disease. Finally an application of Intuitionistic Fuzzy inference in medical diagnosis is discussed.

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