A Survey on the Applications of Fuzzy Logic in Medical Diagnosis

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ABSTRACT
In real world computing environment, the information is not complete, precise and certain, making very difficult to derive an actual decision. Various Clinical Decision Support Systems have been constructed by the aid of Artificial intelligence. These systems are now widely used in hospitals and clinics. They are proved to be very useful for patient as well as for medical experts in making the decisions. An essential element of the medical profession is making numerous decisions. In this process doctors rely on gained knowledge and experience. However, it seems necessary for them to have the ability to think logically, to use reasoning, to infer, to precisely and clearly express their thoughts and justify the assertions made. This paper will present the importance of logic in the medical field.

Key words: clinical decision support systems, fuzzy logic, neural network

1 INTRODUCTION:

The world we live in is full of uncertainty and imprecision in so many ways. In particular, the domain of medical decision making is one driven by problems of vagueness and uncertainty. The doctor makes decisions on treatment based not simply on matching precise symptoms or measurements to diagnosis.

2 CLINICAL DECISION SUPPORT SYSTEMS

Haynes et al defined CDSSs as "…information technology-based systems designed to improve clinical decisions-making. Characteristics of individual patients are matched to a computerized knowledge base, and software algorithms generate patient-specific information in the form of assessments of recommendations" [31].

3 HISTORY OF DECISION SUPPORT SYSTEMS IN MEDICINE

Since computer was invented, it has been used for assisting medical professionals. The first research article dealing with medicine and computers appeared in late 1950s (Ledley & Lusted, 1959). Later an experimental prototype appeared in the early 60s (Warner et al., 1964). At that time limited capabilities of computer did not allow it to be a part of medical domain. In 1970s the three advisory systems: de Dombal's system for diagnosis of abdominal pain (de Dombal et al., 1972), Shortliffe's MYCIN system for antibiotics selection (Shortliffe, 1976), and HELP system for medical alerts delivery (Kuperman et al., 1991; Warner, 1979).1990s witnessed a large scale shift from administrative systems to clinical decision support systems.

4 TYPES OF CLINICAL DECISION SUPPORT SYSTEMS

Clinical decision support systems are broadly classified into two main groups.

- Knowledge based CDSS
- Non-knowledge based CDSS

4.1 Knowledge Based CDSSs:

The knowledge based clinical decision support system contains rules mostly in the form of IF-Then statements. The data is usually associated with these rules. For example if the pain intensity is up to a certain level then generate warning etc., The knowledge based generally consists of three main parts: Knowledge base, Inference rules and a mechanism to communicate. Knowledge base contains the rules, inference engine combines rules with the patient data and the communication mechanism is used to show the result to the users as well as to provide input to the system.

4.1.1 *Fuzzy Logic Rule Based:*

It is a form of knowledge base and has achieved several important techniques and mechanisms to diagnose the disease and pain in patient.

4.1.2 *Rule- Based Systems & Evidence Based Systems*

They tend to capture the knowledge of domain experts into expressions that can be evaluated as rules. When a large number of rules have been compiled into a rule base, the working knowledge will be evaluated against rule base by combining rules until a conclusion is obtained. It is helpful for storing a large amount of data and information. However it is difficult for an expert to transfer their knowledge into distinct rules.

4.2 *Non Knowledge Based CDSS:*

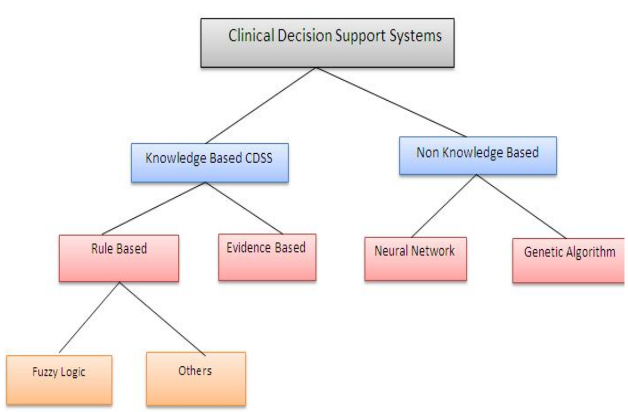
CDSS without a knowledge base are called as non-knowledge based CDSS. These systems instead used a form of artificial intelligence called as machine learning. Non- knowledge based CDSSs are then further divided into two main categories.

4.2.1 *Neural Network:*

To derive relationship between the symptoms and diagnosis, neural networks use the nodes and weighted connections. This fulfills the need not to write rules for input. However, the system fails to explain the reason for using the data in a particular way. So its reliability and accountability can be a reason.

4.2.2 *Genetic Algorithms:*

They are based on evolutionary process. Selection algorithm evaluates components of solutions to a problem. Solution that comes on top are recombined and the process runs again until a proper solution is observed. The generic system goes through an iterative procedure to produce the purpose the best solution of a problem.



5 FUZZY LOGIC

The idea of the Fuzzy Logic was first introduced by Professor Lotfi Ahmad Zadeh, at University of Berkeley, California in his seminal paper “Fuzzy Sets”. Fuzzy Logic is a form of multi-valued logic derived from fuzzy set theory to deal with approximate reasoning. It provides the means to represent and process the linguistic information and subjective attributes of the real world [32].

6 APPLICATIONS OF FUZZY LOGIC IN MEDICAL FIELD

6.1 Tuberculosis

A fuzzy rule based system is designed to serve as a decision support for tuberculosis diagnosis. This system is designed to detect class of *tuberculosis* and these fuzzy rules are updated using rule mining techniques. Based on this method that generates classes of tuberculosis suits the needs of pulmonary physicians and reduce the time consumed in generating diagnosis [1].

A decision support system for diagnosing TB has been developed. Fuzzy logic for medical diagnosis provides an efficient way to assist inexperienced physicians to arrive at the final diagnosis of TB more quickly and efficiently [13].

6.2 Cancer

The four heterogeneous *childhood cancers*, neuroblastoma, non-Hodgkin lymphoma, rhabdomyosarcoma, and Ewing sarcoma present a similar histology of small round blue cell tumor (SRBCT) and thus often lead to misdiagnosis. Identification of biomarkers for distinguishing these cancers is a well studied problem. Multilayer networks with online gene selection ability and relational fuzzy clustering to identify a small set of biomarkers for accurate classification of the training and blind test cases of a well studied data set [28].

Multi-Objective Evolutionary Algorithms based Interpretable Fuzzy (MOEAIF) methods for analyzing high dimensional bio-medical data sets, such as microarray gene expression data and proteomics mass spectroscopy data. This is used in evaluating the *lung cancer* [3].

Fuzzy rules that can be used to process the relevant data from breast cancer cases in order to give a *breast cancer* risk prognosis which can be qualitatively compared to that of an expert. A fuzzy logic technique for the prediction of the risk of breast cancer based on a set of judiciously chosen fuzzy rules utilizing patient age and automatically extracted tumor features [21].

In this study a fuzzy expert system design for diagnosing, analyzing and learning purpose of the *prostate cancer* diseases a design of a fuzzy expert system for determination of the possibility of the diagnosis of the prostate cancer [23].

Neural network system (NN) and a fuzzy inference system were used in this study as promising modalities for detection of different types of *skin cancer* [24].

A neuro-fuzzy system was developed to predict the presence of *prostate cancer*. Neuro-fuzzy systems harness the power of two paradigms: fuzzy logic and artificial neural networks [26].

The Fuzzy Method developed provides breast cancer pre-diagnosis with 98.59% sensitivity (correct pre-diagnosis of malignancies); and 85.43% specificity (correct pre-diagnosis of benign cases). An intelligent method to assist in the diagnosis and second opinion of breast cancer, using a fuzzy method[22].

A new neural-fuzzy approach is proposed for automated region segmentation in transrectal ultrasound images of the prostate. The goal of region segmentation is to identify suspicious regions in the prostate in order to provide decision support for the diagnosis of *prostate cancer* [30].

6.3 Image and signal processing

Fetal electrocardiogram (FECG) signal contains potentially precise information that could assist clinicians in making more appropriate and timely decisions during labor. This paper provides concise information about FECG and reveals the different methodologies to analyze the signal for efficient FHR monitoring [4].

An optimized fuzzy logic method for Magnetic Resonance Imaging (MRI) brain images segmentation is presented .The results of this paper show that the method effectively segmented MRI brain images with spatial information, and the segmented MRI normal brain image and MRI brain images with *tumor* can be analyzed for diagnosis purpose [2].

6.4 Aphasia

Fuzzy probability is proposed here as the basic framework for handling the uncertainties in medical diagnosis and particularly *aphasia* diagnosis. The proposed fuzzy probability estimator approach clearly provides better diagnosis for both classes of data sets. Specifically, for the first and second type of fuzzy probability classifiers, i.e. spontaneous speech and comprehensive model, P-values are 2.24E-08 and 0.0059, respectively, strongly rejecting the null hypothesis [5].

6.5 Pharmacy

Chronic intestine illness symptoms such as sedimentation and prostate specific antigen are used for the design of fuzzy expert system to determine the drug dose. Suitable drug dose for patients is obtained by using data of ten patients. This system minimizes or removes the negative effects of determination of drug dose for helping physicians [6].

6.6 Heart diseases

Fuzzy Expert System for *Heart* Disease Diagnosis designed with follow membership functions, input variables, output variables and rule base and this system simulates the manner of expert-doctor [7].

6.7 Asthma

Asthma is a chronic inflammatory lung disease. An automated system has been developed using a self-organizing fuzzy rule-based system [8].

A fuzzy system for diagnosis and treatment of integrated western and eastern Medicine is developed and the performance of the diagnostic system for **Lung Diseases** diagnosis using fuzzy logic [9].

6.8 Diabetes

The MDLAP system is a promising tool for individualized glucose control in patients with type 1 *diabetes*. It is designed to minimize high glucose peaks while preventing hypoglycemia [10]. A fuzzy logic controller has been proposed to maintain the normoglycaemic for *diabetic* patient of type I [15].

A telemedical monitoring platform, which should include artificial intelligence for giving decision support to patients and physicians, will represent the core of a more complex global agent for *diabetes care*, which will provide control algorithms and risk analysis among other essential functions [27].

Fuzzy measures and similar nonlinear models can be used in pain relief control they can be used to determine the parameters of the model which describes the dependence of the pain relief on the applied stimulation Thus fuzzy measures lead to the determination for a given pain distribution of the optimal pain relief stimulation [11].

Clinical stroke, its diagnosis and treatment is unique to the individual patient, and is best captured by a scientific approach which not only can represent but also measure the changing causal role of known and unknown patient context in determining his/her condition [12].

6.9 Malaria

A fuzzy expert system for the management of *malaria* (FESMM) was presented for providing decision support platform to malaria researchers, physicians to assist malaria researchers, physicians and other health practitioners in malaria endemic regions [14].

6.10 Hypothyroidism

Fuzzy logic is used in diagnosis of pulmonary embolism, cortical malformations, rheumatic and pancreatic diseases, hepatitides and diabetes. A fuzzy inference system that will diagnose the thyroid disease specially *hypothyroidism*[16].

6.12 HIV

The present study proposes a fuzzy mathematical model of *HIV* infection consisting of a linear fuzzy differential equations (FDEs) system describing the ambiguous immune cells level and the viral load which are due to the intrinsic fuzziness of the immune system's strength in HIV-infected patients [17].

6.13 Arthritis

Arthritis is a chronic disease and about three fourth of the patients are suffering from osteoarthritis and rheumatoid arthritis which are undiagnosed and the delay of detection may cause the severity of the disease at higher risk. Thus, earlier detection of arthritis and treatment of its type of arthritis and related locomotry abnormalities is of vital importance. A system for the diagnosis of Arthitis using fuzzy logic controller (FLC) is designed which is, a successful application of Zadeh's fuzzy set theory. It is a potential tool for dealing with uncertainty and imprecision [18].

6.14 Anaesthesia

Fuzzy Logic Based Smart *Anaesthesia* Monitoring System to enhance the developed diagnostic alarm system for detecting critical events during anaesthesia and to accurately diagnose a hypovolaemia event in anaesthetized patients [19].

Fuzzy Expert System for Fluid Management in General *Anaesthesia* developed a fuzzy expert system for fluid management in general anaesthesia [20].

6.15 Menigioma

An algorithm integrating fuzzy-c-mean (FCM) and region growing techniques for automated tumor image segmentation from patients with *menigioma* which is used to correctly locate tumors in the images and to detect those situated in the midline position of the brain [25].

Meningitis is characterized by an inflammation of the meninges, or the membranes surrounding the brain and spinal cord. Fuzzy cognitive maps are used to assist in the modeling of meningitis, as a support tool for physicians in the accurate diagnosis and treatment of the condition [29].

7 END SECTIONS

7.1 CONCLUSION:

This paper provides the several applications of fuzzy logic in medical decision support. Based on this study, future developments of fuzzy control and monitoring technologies in medicine and healthcare can be forecast. Fuzzy logic provides a means for encapsulating the subjective decision making process in an algorithm suitable for computer implementation. As such, it appears to be eminently suited to aspects of medical decision making. Furthermore, the principles behind fuzzy logic are straightforward and its implementation in software is relatively easy.

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