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A STUDY ON FUZZY LOGIC AND ITS APPLICATIONS IN MEDICINE

J.Greeda[#1], A. Mageswari[*2], R. Nithya[*3]

* Assistant Professor, Department of Mathematics, St.Peter's Institute of Higher Education and Research, Chennai, Tamilnadu - 600054, India.

greedaank@gmail.com

* Assistant Professor, Department of Mathematics, , St.Peter's Institute of Higher Education and Research, Chennai, Tamilnadu - 600054, India.

magi2689@gmail.com

* Assistant Professor, Department of Mathematics, , St.Peter's Institute of Higher Education and Research, Chennai, Tamilnadu - 600054, India.

rnithya1511@gmail.com

Abstract - Fuzzy set theory and fuzzy logic are a highly appropriate and relevant source for evolving knowledge-based structures in medicine for accountabilities such as the elucidation, explanation of sets of medical discoveries and outcomes, diagnosis of diseases, mixed diagnosis, the optimal selection of medical treatments, and for real-time observing of patient data.

I) INTRODUCTION

The knowledge of the Fuzzy Logic was first introduced by Professor Lotfi Ahmad Zadeh, in 1956 at University of Berkeley, California in his seminal paper "Fuzzy Sets". Fuzzy Logic is a method of multi-valued logic resulting from fuzzy set theory to deal with imprecise reasoning. It is responsible for the means to signify and progress the linguistic information and subjective aspects of the real world. Fuzzy set theory and fuzzy logic are a highly appropriate and relevantsource for evolving knowledge-basedstructures in medicine for accountabilities such as the elucidation, explanation of sets of medical discoveries and outcomes, diagnosis of diseases, mixed diagnosis, the optimal selection of medical treatments, and for real-time observing of patient data.

II) FUZZY LOGIC

Fuzzy Logic resembles the human decision-making methodology. It deals with vague and imprecise information. This is gross interpretation of the real-lifedifficulties and based on degrees of truth quite than usual true/false or 1/0 like Boolean logic.

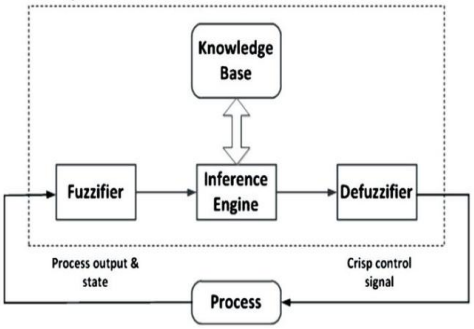
Fuzzy logic an extension of Boolean logic based on the mathematical concept of fuzzy sets, which is a broad view of the classical set theory.

In other words, fuzzy logic is not logic that is fuzzy, but logic that is used to designate fuzziness

III) COMPONENTS OF A FUZZY LOGIC SYSTEM

Four basic components of the fuzzy logic system are as follows:

- Fuzzifier
- Inference engine
- Knowledge base
- Defuzzifier



a)Fuzzifier:

The fuzzifier is the part responsible for fuzzification. It is the process of renovating to transforming a crisp object into a fuzzy set, to a grade of membership function for linguistic variables of fuzzy sets.

b)Inference engine:

After fuzzification, the resultant fuzzy sets (that are still input values) are processed in the inference engine according to the rules of the rule base. The inference engine is the processing unit of the fuzzy logic system.

c)Knowledge base:

This is the most important part of a fuzzy logicsystem. The concert of an fuzzy logic system depends on its knowledge base. The knowledge base of an fuzzy logic system is composed of a database and a rule base.

A knowledge base can be constructed either by experts or self‑learning algorithm.

- The first way is using experts to construct rule base. Experts of the proposed system describe the fuzzy if‑then rules.
- The second way is using the self‑learning algorithm to construct the rule base. For these types of rule base, a part of the cases is used to train the system and construct the rule base while the other part of the cases is expected to be solved by the system. These types of self‑learning systems are called **neuro‑fuzzy systems**.

Knowledge-Based Systems in Medicine

Medicine naturally spread over linguistic concepts to ideal medical knowledge such as disease descriptions, treatment recommendations, prognostic information, and best medical practice management guidelines. Directly observed and measured patient data from patient history, physical examination, laboratory tests, and clinical investigations are usually interpreted and associated.

A data-to concept conversion step links the observational and measurement level with the concept and knowledge level. Any data-driven knowledge-based system includes such a conversion step. Non-interpreted observed or measured (syntactic) data are transformed into interpreted, significant (semantic) information concerning the patient. This functionality is the first step to cleverness in knowledge-based systems in medicine.

d)Defuzzifier:

- Normally, the output of the inference engine is also a fuzzy set, which is not useful in the real world. Thus, it needs to be transformed into the useful and understandable value to be used in the real world.
- The crisp output of the fuzzy output set should be a value, fabricated by taking into account all the points in this fuzzy output interval and by employing high membership degree values more than the ones with small or no membership degree.

IV) FUZZY LOGIC AND ANESTHETICS

The anesthetic experts manage the consciousnessand unconsciousness, pain and its relief, movement of muscles and relaxation during prescribed time range In the operation theatre anesthetized patient is part of a 'feedback circuit'for the period of an operation.

During inspect the consistency of the patients, if any change occurs in blood pressure and respiratory rate then regulate the ventilation and modify the drug dosages. In this process anesthetist will play the role of decision-maker and controller, who will make his own decision to perform best.

While a series of ventilated patient present, fuzzy logic database monitors CO_2 and ends tidal CO_2 and different ventilator frequency and tidal volume to possess end-tidal CO_2 at a preferred level.

The performance of system was not less well than the anesthetist usual practice under similar conditions. Fuzzy logic have been applied to measure the heart rate, tidal volume, breathing frequency and oxygen saturation , to generate the requirement for pressure support ventilation in intensive care.

V) FUZZY EXPERT SYSTEM IN MEDICINE

Medical practitioners exhibit variation in decision making because of their approaches to deal with uncertainties and vagueness in the knowledge and information. The diagnostic decisions also depend upon experience, expertise and perception of the practitioner. As the complexity of system increases, it is not easy to follow a particular path of diagnosis without any mistake.

The Fuzzy Expert Systems (FES) state vague knowledge and suggests linguistic concept with tremendous approximation to medical texts. Fuzzy logic is a method to solidify precise what is imprecise in the world of medicine. FES shows an important role in medicine for symptomatic diagnostic cures.

The technocrats identified potential and possible areas for implementation of FES for medical diagnosis. Also, the determinations have been made by various scholars to launch a road map to forecast the future developments of expert systems in medical diagnosis.

The expert systems are reported for the patient monitoring, prediction of conditions, handling of fuzzy queries in medical applications as well as evaluation and comparison of the enactments with existing practices.

VI) APPLICATIONS OF FUZZY EXPERT SYSTEMS IN MEDICAL DIAGNOSIS

Human thinking and decision building is fuzzy, comprising a high degree of vagueness in proof and concept application and requires a high level of uncertainty controlling in medical diagnosis.

There are several causes of imprecision and uncertainty in an expert systems domain. The result to problems in the domain may be imprecise. For example, this is true of most medical complications.Researchers have proposed numerous innovative fuzzy expert systems to deal with vagueness and complexity and offered the practical aids to users in the form of fuzzy expert systems.

Intellectual medical systems are planned with a motivation on specific disease for the support of decision process. The patient observing, estimation of conditions, handling of fuzzy demands as well as evaluation and comparison of the enactments with existing practices are also been the areas of interests of examiners. The educational outfits have been developed using fuzzy logic approach to support the handlers.

In the testified studies, the requirement, prominence, prospective, necessity of fuzzification and methodologies for manipulative of medical diagnosis expert systems are conversed.Some studies have been accompanied to demonstrate the fitness of fuzzy set theory and its derived theories for developing knowledge based systems and fuzzy sets to model the medical theories.

Decision support systems for diagnostic resolutions of human diseases helped patients and experts to a great extent.Developers have prolonged the use of fuzzy logic theory in scheming disease specific and decision theoretic expert systems for common diseases.

Fuzzy methodology has been discovered to deal with occurrence of vagueness in the general practitioner style of thinking and computer supported expert systems for decision making.Computer supported applications for patient's diagnosis and treatments seems to be the more topical area of importance.Web based fuzzy expert systems are testified for diagnosing human diseases.

The non-disease areas of uses are found to be in: x-ray mammography, elucidation of mammographic and ultrasound images, electrographic exploration of human body.The presentation of fuzzy expert system and decision tree for collection of remedy in homoeopathy is in the middle of the occasional application.

The further areas of applications of fuzzy logic are: prediction of aneurysm, fracture healing and in non-stationary FES, intuitionistic fuzzy sets.

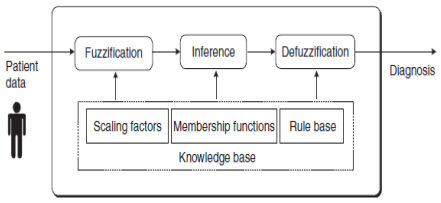
The Fuzzy Expert System has supported its effectiveness knowingly in the medical identification for the numerical analysis and qualitative assessment of medical records, consequently attaining the correctness of results. The computer built diagnostic tools and knowledge base positively helps for early diagnosis of diseases. The growth of web based applications and interfaces permitted the medical physicians to share their experiences and expertise through the world. The development of disease specific presentations using FES for medical diagnosis is witnessed to be the area of biggest interest .

Fuzzy expert systems have recognized to be useful in the medical diagnosis for the quantitative analysis and qualitative evaluation of medical facts, by succeeding the correctness of outcomes. The development of disease specific FES applications is the area of biggest concern to the researchers. Fuzzy expert systems in medical field are used for,

• Knowledge acquisition
• Dealing with inconsistencies
• Treatment planning
• Advisory, monitoring, and control of systems
• Parameters predictions
• Artificial thinking.

VII) MEDICAL DIAGNOSIS

The attitude of medical diagnosis has two main components namely symptoms as input and the output as a disease.



Medical artificial intelligence is concerned with the structure of artificial intelligence sequencers that bring about identification, analysis and make therapy references. Unlike medical uses founded on alternative programming method such as morally

statistical and probabilistic ways and means, medical AI programs are constructed on symbolic simulations of disease entities and their relationship to patient factors and clinical exhibitions.

Medical expert structures hold medical facts, usually about a very precisely defined task, and are able to reason with data from distinct patients to come up with reasoned inferences. Fuzzy logic is a superset of probable (Boolean) logic that has been elongated to handle the concept of partial truth – truth values between "totally true" and "totally false.

The common structure of a fuzzy system to be used as the core part of a fuzzy claim. The structure can be summarized in the following four steps, carried out in order:

(i)Fuzzification:

The membership roles is well-defined on the input variables are functional to their accurate values, to direct the degree of truth for each one rule premise.

(ii)Inference:

The truth value for the idea of each rule is computed, and applied to the deduction part of each rule. This result in one fuzzy subset to be hand over to each output variable for each rule.

(iii)Composition:

All of the fuzzy subsets assigned to each output variable are united together to form a only fuzzy subset for each output variable.

(iv)Defuzification:

It is an optional step which is used when it is useful to convert the fuzzy output set to a crisp number. Medical diagnosis usually consist of careful examination of a patient to check the occurrence and strength of some features relevant to a distrusted disease in order to take a decision whether the patient suffers from that disease or not. A feature, like a runny nose for case, may appear to be very strong for one patient but it can be moderate or even very light for another. It is the experience of the general practitioner that tells him how to combine a set of symptoms (features and their strengths) to find out the correct diagnostic decision.

VIII)DIAGNOSIS OF DISEASES

a)Tuberculosis:

A fuzzy rule based system is intended to assist as a decision support for tuberculosis diagnosis. This system is designed to discover class of tuberculosis and these fuzzy rules are modernized using rule mining techniques. Based on this method that produces classes of tuberculosis suits the requirements and essentials of pulmonary general practitioners and condense the time consumed in engendering diagnosis.

A decision support system for make out diagnosis of TB has been urbanized. Fuzzy logic meant and designed for medicaldiagnosis provides an proficient way to promote in experienced doctor of medicine to arrive at the ultimateconclusion in diagnosis of TB more speedily and efficiently.

b)Cancer:

The four various **infantile cancers** are, neuro-blastoma, non-Hodgkin lymphoma, rhabdomyosarcoma, and Ewing sarcoma be existent a similar histology of slight round blue cell tumor (SRBCT) and as a outcome often lead to misdiagnosis.

Credentials of biomarkers for distinctive these cancers is well studied . Multilayer systems with in operation accessible gene collection ability and interactive fuzzy clustering to identify in

consequential set of biomarkers for accurate arrangement of the working out and unsighted test cases of a well-studied data set.

Multi-Objective Evolutionary Algorithms initiated Interpretable Fuzzy (MOEAIF) approaches for scrutinizingin elevation dimensional bio-medical record document and data sets, such as microarray gene manifestation data and proteomics mass spectroscopy data. This is used in assessing the

*(c)**lung cancer:***

Fuzzy instructions that can be used to progress the appropriate data from **breast cancer** cases in mandate to give a breast cancer risk prospects which can be qualitatively equated to that of an expert.

A fuzzy logic performance for the extrapolation of the risk of breast cancer based on a set of thoughtfully elected fuzzy rules make the most of patient age and spontaneously put in tumor features.

In this education a fuzzy expert system intent objective for diagnosing, inspecting and learning persistence of the **prostate cancer** diseases a project of a fuzzy expert system for strength of character of the possibility of the diagnosis of the prostate cancer.

Neural network system (NN) and a fuzzy inference system are used in this study as

Encouraging and favourable modalities for revealing of different types of **skin cancer**. A neuro-fuzzy system was technologically advanced to predict the existence of **prostate cancer**. Neuro-fuzzy systems tie together the power of two paradigms: fuzzy logic and artificial neural networks.

The Fuzzy Method urbanized be in charge for breast cancer pre-diagnosis with 98.59% thoughtfulness(correct pre-diagnosis of malignancies); and 85.43% specificity (correct pre-diagnosis of benign cases). A quick intellectual manner to contribution in the diagnosis and second outlook of breast cancer, using a fuzzy method.

A diverse extremes apart neural-fuzzy attitude is put forward for mechanized section segmentation in transracial ultrasound descriptions of the prostate. The objective of region segmentation is to as certain apprehensive regions in the prostate in order to arrange for decision support for the diagnosis of **prostate cancer**.

(d)Diabetes:

The MDLAP system is a encouraging tool for personalized glucose control in patients with type 1 diabetes. It is intended to minimize high glucose peaks while precluding hypoglycemia.A fuzzy logic controller has been anticipated to uphold the normoglycaemic for diabetic patient of type I.

A tele-medical monitoring platform, which ought to include artificial intelligence for generousdecision support to patients and doctors, will signify the core of a more complex global agent for diabetes care, which be responsible for regulating algorithms and risk analysis among other indispensible purposes .Fuzzy processes and similar nonlinear simulations can be used in pain relief control they can be used to govern the parameters of the model which describes the dependence of the pain relief on the applied inspiration. Thus fuzzy procedures mainly leads to the resolve for a given pain distribution of the finest pain relief stimulation.

Clinical stroke, its analysis and treatment is distinctive to the individual patient, and is best seized by a scientific line of attack which not only can epitomize but also measure the varying causal role of known and unknown patient context in determining his/her condition.

(e)Anaesthesia:

Fuzzy Logic Based Smart anesthesia Monitoring System to enrich the developed diagnostic alarm system for distinguishing critical events during anaesthesia and to precisely diagnose a hypo volaemia occasion in anaesthetized patients.

Fuzzy Expert System for Fluid Management in General anesthesia technologically advanced a fuzzy expert system for fluid management in general anesthesia.

IX)PROBLEMS ON MEDICAL DIAGNOSIS

The operational function of the human body is regarded as by the complex and highly interactive interplay of its body part and the psyche. The goal of this determined effort is homeostasis, the steadiness and stableness of all physiological extents. While the authentic level at which the balance is preserved varies within physiological bounds from individual to individual, deviations from it are suggestive of some kind of perturbation, be it of internal or of external cause. The credentials of these distresses is the goal of medical diagnosis.

With the problem-solving means available today it is often impossible to look inside a sickening patient and govern the primary cause that led to the (series of) special effects and reactions the patient protests about. More often than not, diagnosis is therefore based on indirect indication, the presence of symptoms, and the knowledge of the medical mechanisms that relate presumed causes to observed effects.

The problems of diagnosis do not only get up from the incompleteness of this facts, but also and most immediately from the theoretical and practical limitations associated with the setback misfortune of the chain of consequences that lead from an initial cause to its observable effects.

First of all, medical cause-effect associations, the relations flanked by diagnoses and their symptoms, are hardly ever one-to-one. Inconsistency of diagnoses that share an partly cover range of symptoms is therefore inherently difficult. Moreover, all statement is subject to error: the correction of this error, stochastic in nature, requires strong assumptions that do not hold in practice. Lastly, the required clarifications can often not be made on a constant basis.

Quite to the opposing: Because many diagnostically eloquent observations can only be obtained atreasonably high or cost, one has to make do with suggestively less than desirable information.

This is vaguely a tricky for the diagnosis of dynamic disconcertion that go forward over an long-drawn-out period of time: gapless recording of the time course of physiologically influential parameters is still more a desideratum than reality. Diagnosticians are left with a lot to speculate about.

Even though taken alone none of the problems is irreplaceable to the medical domain, taken together they add to an sophistication exceeding that of even the most refined man-made systems known today. It is therefore realistic to expect that medical diagnosis will for a long time remain problematically tricky.

How fuzzy sets can help

It seems quite clear that system notional, analytic resolutions to the problems of medical diagnosis are very unbreakable to find. On the other hand, the cleverness of a human diagnostician is necessary to achieve adequate results in the vast widely held of diagnostic problems posed.

Certainly, this enactment cannot be explained by non-reproducible processes such as estimating or

intuition. There must be some arrangement to diagnosis susceptible to reinforcement an automated reproduction. The credentials of such structure and associated methods is a key goal of medical AI. It has brought out two basic attitudes to diagnosis.

One, referred to as exploratory diagnosis, is associative in nature and relies on the standing on ceremony experience of experts in the field (which is often phenomenological or case-based). The other, called model-based diagnosis, builds on a profounder understanding of the matter of discourse and uses models to imitate the diagnosed subject's behaviour.

The former is an challenge to reverse the physiologic cause-effect relationships directly, while the latter tries to originate the observed symptoms from put forward diagnoses, simulating the known relationships and so formative the cause indirectly.

It is not challenging to see how fuzzy set theory can help with heuristic diagnosis. Every trustworthy expert knows that his/her medical knowledge and the resulting diagnoses are pervaded by uncertainty. Uttered expert knowledge therefore a bounds with imprecise formulations. This imprecision is not a consequence of rhetorical inability, but an intrinsic part of expert knowledge acquired through laborious experience. Any formalism disallowing uncertainty is therefore in apt to capture this knowledge stripping it of its uncertainty entails the danger of fallacies due to misplaced precision.

Fuzzy set theory on the other hand was conceived with the formalization of vague knowledge in mind. Together with appropriate rules of inference it provides a powerful framework for the combination of evidence and deduction of consequences based on knowledge specified in syllogistic form.

Not so obvious is the suitability of fuzzy set theory for model-based diagnosis. Yet, an intrinsic need for fuzziness in the models themselves has been observed: "Indeed, the complexity of biological systems may force us to alter in radical ways our traditional approaches to the analysis of such systems.

Thus, to consent as unavoidable a significant degree of fuzziness in the description of the behaviour of biological systems as well as in their categorization.

This fuzziness, repulsive though it may be, is the price we have to pay for the ineptitude of precise mathematical techniques in dealing with systems encompassing a very large number of interacting elements or involving a large number of variables in their decision trees. In model-based diagnosis, precision would be as misplaced as in heuristic diagnosis.

The generality of fuzzy set theory allows literally all models, as well as the ontologies within which they are created, to be fuzzified; resultant is a treatment of uncertainty that lies at the intersection of qualitative and quantitative methods.

CONCLUSION

Fuzzy logic is a useful tool to implement key concepts such as control regulation , adaptation, communication and organization. Fuzzy set theory and its consequent theories make available ahighly appropriate and generally applicable basis for developing knowledge-based systems in medicine. Clinical studies conducted demonstrated the suitability of the respective patient data and fuzzy knowledge representation and the selected fuzzy inference mechanisms with respect to the essential medical applicability and attained accuracy of results. They further discovered the instant intuitive

understanding of basic ideas of fuzzy set theory and fuzzy logic on the part of medical users. The complexity of medical practice makes traditional quantitative approaches of analysis inappropriate. In medicine the lack of information, and its imprecision ,and many times contradictory nature are common facts. Health is a vital indicator of human development that will enable every individual to lead a social and economically productive life. Sanchez's medical diagnosis method applying the algorithms to the illustration analyzes the disease from which the person is suffering from. The basics of Fuzzy logic and its application areas in medical domain are given together with the techniques employed.

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