Advances in Computer Science and Information Technology (ACSIT)
Print ISSN: 2393-9907; Online ISSN: 2393-9915; Volume 2, Number 8; April-June, 2015 pp. 57-62

http://www.krishisanskriti.org/acsit.html

Design and Identification of Tuberculosis using Fuzzy Based Decision Support System

Navneet Walia[1], Sharad Kumar Tiwari[2] and Rahul Malhotra[3]

[1,3]CT Institute, Jalandhar
[2]Thapar University, Patiala
E-mail: [1]navneetwalia356@gmail.com, [2]sktiwari@thapar.edu, [3]blessurahul@gmail.com

Abstract—*This paper introduces a systematic approach for design of fuzzy expert system for diagnosis of tuberculosis. Fuzzy system is presented for providing decision support platform to tuberculosis researchers and for pulmonary physicians that are already focusing on tuberculosis. The main focus of this paper is for development of system architecture and algorithm used to find stage of tuberculosis a patient may have. This is achieved by employing Mamdani's MAX-MIN fuzzy inference engine to infer data from rules developed. This resulted in the establishment of degree influencing input variables on the output. The technique allows for less, mild, moderate, high, yes and no symptoms to be applied in order to get the estimation result. This system will offer potential assistance to medical practitioners and healthcare sector in making prompt decision during the diagnosis of tuberculosis.*

Index Terms*: Fuzzy inference system, Expert System, Rule based diagnosis, Tuberculosis (TB).*

1. INTRODUCTION

Tuberculosis (TB) was believed to be almost under control, but still it is a serious worldwide problem. Detection of bacteria is very important in order to prevent its growth and maintain health of the world's population. Various types of bacteria exist, some bacteria are beneficial to humans and some are harmful. Tuberculosis disease is caused by one of bacteria called mycobacterium tuberculosis [1]. As it is communicable disease it can be transmitted through the air when the infected person cough, sneeze or from saliva. This disease was discovered by Robert Koch in 1882. Tuberculosis disease is caused by a bacterium which is called as Mycobacterium tuberculosis. Pulmonary tuberculosis is a contagious bacterial infection that involves lungs, but may spread to other organs. Tuberculosis disease occurs under different manifestations on adults and children. When the first encounter happens with bacillus, which mostly happens on the childhood phase of a person, lymphatic glands that are located at the entry point of the lungs are picked by this microorganism for the first rooting point on the body. As a result of this event, those glands enlarge (hilar lymphadenopathy) and this called as primary tuberculosis. The adult type (secondary) tuberculosis is different from this scenario. In those cases, the person's lung is contaminated with the microorganism before. If the immune system is strong enough, microorganism cannot cause any sickness but can keep itself alive. When the immune system of the person weakens for a reason, microorganism gets activated and begins to create sickness [11]. Typical outward indications of pulmonary tuberculosis include persistent cough, chest pain, haemoptysis, and occasional fever, loss of appetite, smoke addiction, BCG vaccine, malaise and Weight reduction. The relations between diagnoses and their symptoms are hardly ever one-to-one, thus, differentiation of diagnoses that share an overlapping range of symptoms is therefore inherently difficult. Most diagnostic systems are in the form of a rule-based expert system: a set of rules is used to describe certain patterns. Observed data are collected and used to evaluate these rules [7].

In medicine, it is not necessary to deal with micro phenomena and microobjects to run into the problems of incompleteness, uncertainty, and inconsistency. The lack of information, and its imprecise and sometimes contradictory nature, is much more a fact of life in medicine than in, say, the physical sciences. These problems have to be taken into account in every medical decision, where they may have important, even vital consequences for the object of medical attention the patient [16]. The major objective of this work is to develop a prototype warning system for clinical activity, based on the assumption that clinical problems can be analyzed in many simple rules and the decision process of the physician can be modeled by sets of these rules, in fuzzy logic every variable is described by a fuzzy set [8]. A fuzzy inference system employs fuzzy if-then rules can model the qualitative aspects of human knowledge and reasoning processes. Fuzzy sets are an aid in providing symbolic knowledge information in a more human comprehensible or natural form, and can handle uncertainties at various levels [2]. Fuzzy systems are very useful in two general contexts: (i) Situations involving highly complex systems whose behaviors are not well understood, and (ii) in situations where an approximate, but fast, solution is warranted [3].

In this paper, we discuss about a medical expert system in which we use fuzzy logic to identify the disease stage from its symptoms which helps to develop fuzzy rules that can be stored in the knowledge base and can be fired during further decision process [8].

2. REVIEW OF RELATED WORK

In this section, we will introduce some related work about fuzzy logic. A detailed survey of fuzzy logic techniques may be found in this section. There are many works in the literature that explains about the design and implementation of medical expert systems. Fuzzy set theory, which was initially introduced by Lofti Zahed in 1965, makes it possible to define inexact medical entities as fuzzy sets. It is a powerful tool to deal with the imprecision characteristics in decision making problems involving uncertainty and vagueness of real world applications [4,5]. It offers a linguistic approach that represents an excellent approximation to medical texts [16]. His paper on fuzzy sets gave an insight into a kind of logic which is finding an increasing usage in day to day lives. It is a form of multi-valued logic and deals with reasoning. The imprecision of human reasoning needed to be more efficiently handled. In 1971, Zadeh published the concept of quantitative fuzzy semantics which in turn led o the methodology of fuzzy logic and its applications [9]. Since 1975, Dr. Edward Shortliffe, Feigenbaum and Buchanan had developed the fist expert system known as MYCIN. MYCIN used to assist physicians to administer blood infection treatment from diagnosis of infectious blood diseases to subsequent recommendation of antibiotics, with the dos-age prescription based on the patient's body weight. ONCOCIN was developed in the early 1980s with the aim of assisting physicians in the management and treatment of cancer patients [15].

Expert system of medicine is became an important issue. There are some medical diagnostic systems based on BPN (Back propagation network): "The expert system for dermatology diagnosis", "The diagnosis for acute coronary occlusion" and "The early diagnosis of heart attacks" was proposed. Beside above systems, it also has some Chinese medical diagnostic system based on BPN: "zhaosong-quan Chinese medical expert system of infertility" (Beijing obstetrics and gynecology hospital), "Composite international diagnostics system" (Beijinghui-guan hospital), and "The program of Chinese medical liver complaint diagnosis" (Beijing Chinese medicine hospital) was presented [8]. A hybrid medical expert system called XBONE was developed in 1997, and it uses a hybrid representation formalism to integrate rules and an Adaline artificial neural unit for bone disease diagnosis using patient's clinical, demo-graphic, and scintigraphic (nuclear medicine image (NMI)) data. EpiMAN-TB was discussed by McKenzie et al. is a decision-support system using spatial information for the management of TB in cattle and deer, which works by prediction of possum TB hot spots. Expert system (ES) for tuberculosis diagnosis known as TUBERDIAG14 was developed in 1999 by Nguyen et al. as a fuzzy logic and approximate reasoning system [15].

A novel approach based on a web based medical expert system in which the web server provides an interface between hospital information systems and home doctors was discussed by Shusaku Tsumoto (1999). According to them, the recent advances in computer resources have strengthened the performance of decision making process and the implementation of knowledge base operations [8]. A computational web-based technique was proposed by Vladimir Androuchko et al. (2006) which have a powerful engine to perform all necessary operations. The system architecture presented by them is highly scalable, modular, and accountable and most importantly enables the incorporation of new features that has to be economically installed in future versions. Sanchez et al. implemented data mining technique to classify TB related handicaps to determine patients' sickness. This study was classifying tuberculosis diagnostic categories based on given variables. Records of 1,655 patients having 56 attributes are used as raw data set. Those 56 attributes are reduced into 5 attributes which are antecedents, bacteriology results, age category, pulmonary tuberculosis and extra pulmonary tuberculosis. Exhaustive Chi-squared automatic interaction Detector (CHAID) is selected for generating decision trees for classes [11]. A medical expert system for managing tropical diseases was proposed by (Adekoya et al., 2008). The proposed Medical Expert Solution (MES) system was to assist medical doctors to diagnose symptoms related to a given tropical disease, suggest the likely ailment, and advances possible treatment based on the MES diagnosis [8].

3. MATERIALS AND METHODS

Fuzzy systems implements nonlinear systems using linguistic variables in a straightforward when enough knowledge about the system is available. Fuzzy logic module was used as decision-making tool to resolve any uncertainty in the decision made by the neural networks [6].

In this section, preparing tuberculosis data set and implementation of the fuzzy inference system are considered for diagnosing the disease of the TB patients. In order to obtain best prediction model of tuberculosis disease, data set of 35 patients was collected from government health clinic. The FIS were constructed with 9 inputs. The fuzzy rules base decision system adopts expert knowledge and experience to deal with patient symptoms and make appropriate decision according to prescribed fuzzy rules.

3.1. Domain values of input variables

Input data attributes of the data set is based on demographics data and clinical findings. In the first group, the *cough* parameter is categorized into three classes the patients have, ‘0’ indicates cough less than 2 weeks, ‘1’ indicates cough is between 2 to 3 weeks, ‘3’ indicates cough is more than three weeks. *Smoke addiction* parameter defines whether the patient is a non smoker or smoker. Smoke addition classified into three subgroups, ‘‘0’’ means the patient is not a smoker, ‘‘1’’ means the patient smokes less than eight cigars per day, ‘‘2’’ means the patient smokes between 6 and 10 cigars per day. *BCG* vaccine shows the whether the patient has BCG vaccine or not. *Malaise, loss of appetite, loss in weight and chest pain* has binary valued parameters. They indicate whether these parameters are positive for the patient or not. *Haemoptysis* means coughing up blood from the respiratory tract. This parameter identifies whether the patient suffers from haemoptysis or not. Fever is classified into three categories: ‘‘0’’ means normal fever value which is nearly 36.5 C, ‘‘1’’ means fever value is in high ranges, and ‘‘2’’ means subfebrile fever value which does not exceed 38.5 C. Table 1 lists the input variables with their data types and data domains.

Table 1: List of types and domain values of variables

Variable Name	Data type	Acceptable values
Coughing	Integer	0 mean <2weeks, 1 mean between 2 to 3, 3 mean > 3 weeks
Chest pain	Boolean	No = 0, yes = 1
Haemoptysis	Boolean	No = 0, yes = 1
Fever	Integer	Normal = 0, high =1, subfebrile = 2
Loss of Appetite	Boolean	No = 0, yes = 1
Smoking addiction	Integer	None = 0, little (6 items)=1,moderate (6–10 items) = 2
BCG vaccine	Boolean	No = 0, yes = 1
Weight loss	Boolean	No = 0, yes = 1
Malaise	Boolean	No = 0, yes = 1

3.2. Diagnosis of TB using Fuzzy inference system

Fuzzy logic model can be viewed as a way to convert expert knowledge into an automatic control strategy without any detailed knowledge of the problem. It is mainly composed five components (fuzzification, defuzzification, database, fuzzy rule base inference engine), as shown in “Fig. 1”. In this paper we proposed rule based Fuzzy Diagnostics is a decision support system that are intended for pulmonary physicians, this will analyze the stage of tuberculosis. Fuzzy systems are fuzzy model structures in the form of fuzzy rule bases (FRBs) that are the most important area in the application of the fuzzy set theory. Designing a fuzzy rule based system involves derivation of the desired ‘If-Then’ fuzzy rules, partitioning of universes, and addressing of the membership functions [17]. Fuzzy rule base is updated with dynamic rules. Tuberculosis symptoms and stage details are updated in rule base. As the patient must have a history in tuberculosis, then the proposed system using Fuzzy logic as the tool used to develop the algorithm of the system. By using this fuzzy logic, the system provides a workspace in which physicians will input corresponding scores of each symptom the patient exhibits. The intensity varies depending on the symptom, then the system will evaluate and allocate the stage of tuberculosis the patient has. Fuzzy set theory has a number of properties that make it suitable for formalizing the uncertain information upon which medical diagnosis and treatment is usually based. Firstly, it defines inexact medical entities as fuzzy sets. Secondly, it provides a linguistic approach with an excellent approximation to texts. Finally, fuzzy logic offers reasoning methods capable of drawing approximate inferences [16].

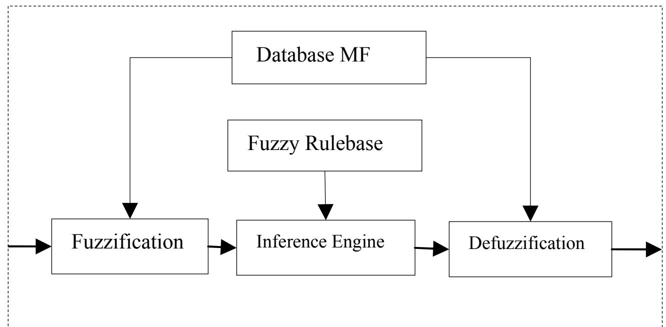


Fig. 1: Framework of Fuzzy inference system

Fuzzy Logic was the tool used to develop the algorithm of the proposed system. With fuzzy logic, the researchers were able to classify the intensity of each symptom according to its description given by pulmonary physicians interviewed. Rule-based method is one of the objectives in developing the system. A set of rules was used based on the physicians’ experience that will aid in diagnosing the class of tuberculosis [18]. Fuzzy logic toolbox in Matlab R2013a is employed in this paper for the membership function plots of inputs as shown in “Fig. 2-7”.

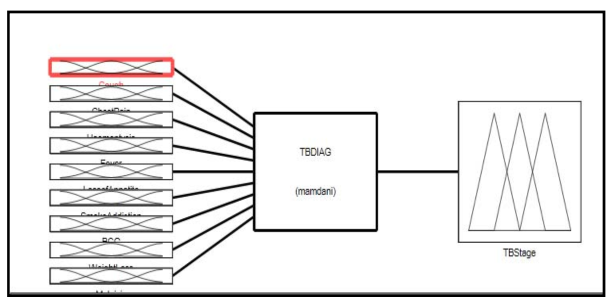


Fig. 2: Fuzzy inference system for Healthcare

Diagnosis of Tuberculosis

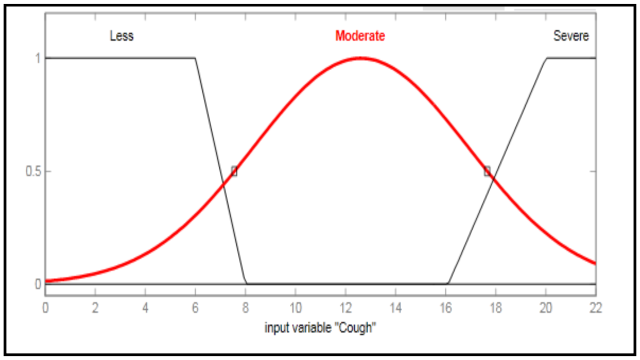


Fig. 3: Membership Function Plot for Cough

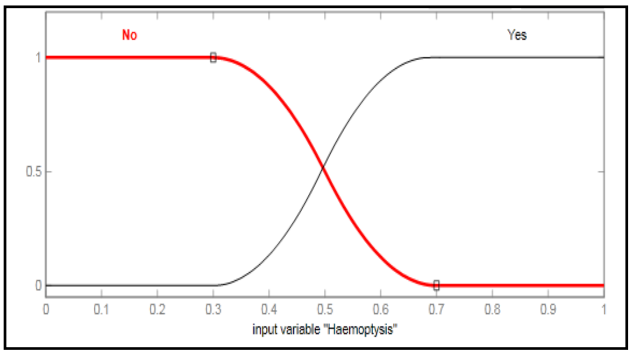


Fig. 4: Membership function plot for Haemoptysis

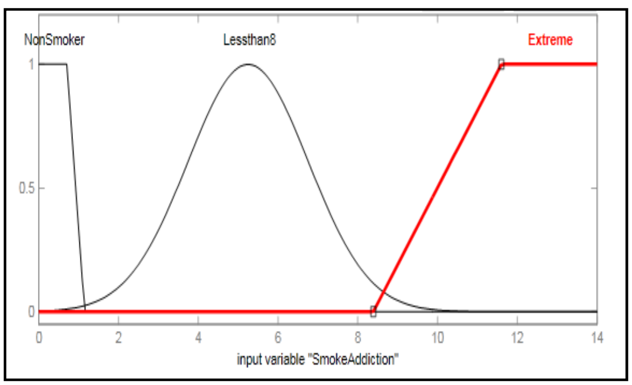


Fig. 5: Membership Function Plot for Smoking

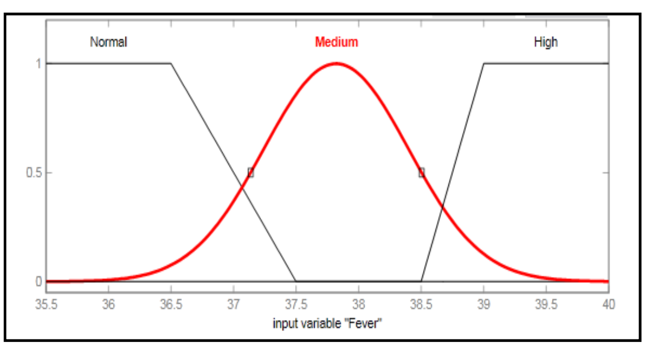


Fig. 6: Membership Function Plot for Fever

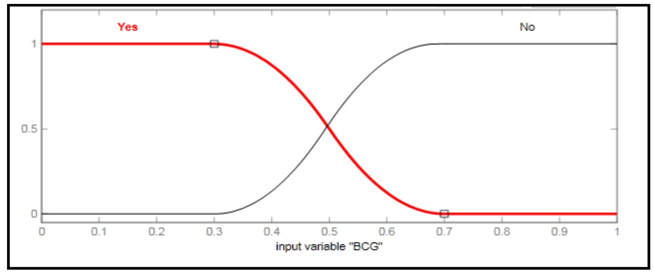


Fig. 7: Membership Function Plot for BCG

By using Fuzzy Logic tool, the researchers were able to classify the intensity of each symptom according to its description given by pulmonary physicians interviewed. After processing the calculations, the resultant scores were graphed in a symmetrical manner. The graph will illustrate the scores and its corresponding membership values.

4. EXPERIMENTAL RESULTS

Fuzzy rules and fuzzy reasoning are the backbone of fuzzy inference systems, which are the most important modeling tools based on fuzzy sets [10]. Fuzzy if-then rules are production rules including antecedent parts, and consequent part. Fuzzy reasoning is an inference procedure that derives conclusions from the set of fuzzy If-Then rules and known facts. "Fig. 9" shows the fuzzy reasoning procedure for diagnosis of bacterium. Since each rule has a crisp output, the overall output is obtained via a weighted average, thus avoiding the time consuming process. Usually, $z = f_i(x,y)$ is a polynomial in the input–output variables x and y, but it can be any function as long as approximately describing the output of the model within the fuzzy region specified by the antecedent of the rule.

The input parameter of system under consideration are cough(C), chest pain(CP), haemoptysis(H), fever(F), loss of appetite(LA), smoke addiction(S), BCG, weight loss(WL), malaises(M) and output is stage of bacterium. These imprecise attributes are called fuzzy linguistic variables are used in diagnosis system. These linguistic variables are imprecise, vague and incomplete fuzzy terms. They are introduced and expressed by fuzzy linguistic values such as 'mild (A1), moderate (A2), severe (A3), very severe (A4) as is given in "Fig 8".

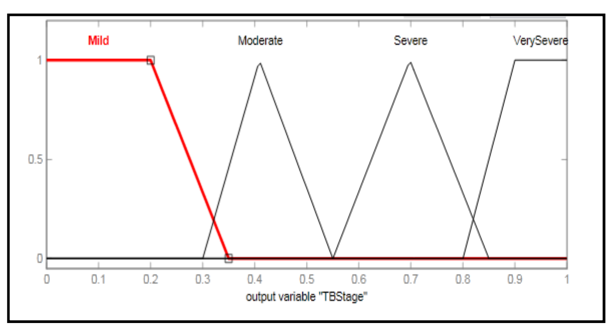


Fig. 8: Fine tuned membership plot of output variable

The degree of membership (DOM) is determined by plugging the selected input parameter into the horizontal axis and projecting vertically to the upper boundary of the membership function(s). Fuzzy Logic tool is used the outputs of the rule-based and the ranges of scores the physicians input in order to determine the class of tuberculosis the patient has [8]. The matrix illustrates the symptoms are between the intersection points. The values that undergone defuzzification were used to formulate the rules that correspond to the different conditions determined by the matrix as shown in "Table II". A rule-based method makes it easy to store a large amount of information, and coming up with the rules will help to clarify the logic used in the decision-making process [18].

Table 2: Fuzzy Rulebase for Tuberculosis

Rule No.	IF									THEN
	Cough	**Chest Pain**	**Haemoptysis**	**Fever**	**Loss of Appetite**	**Smoke Addict.**	**BCG vaccine**	**Weight Loss**	**Malaise**	**Conclusion**
1.	Less	No	No	Normal	Yes	Less	No	Yes	Yes	Mild
5.	Less	Normal	No	Normal	No	Extreme	Yes	Yes	Yes	Mild
15.	Less	Yes	No	High	Yes	Extreme	Yes	Yes	Yes	Moderate
25.	Less	No	No	High	No	No	No	Yes	Yes	Moderate
90.	Less	No	No	High	No	Less	No	Yes	Yes	Severe
106.	Less	No	No	Severe	Yes	No	No	Yes	Yes	Moderate
119.	Less	No	No	Severe	Yes	Extreme	No	No	No	Moderate
146.	Less	No	No	Severe	No	Extreme	No	Yes	Yes	Moderate
178.	Less	No	Yes	Normal	No	No	No	Yes	Yes	Severe
257.	Less	No	Yes	Severe	Yes	Less	No	Yes	No	Severe
290.	Less	No	Yes	Severe	No	Extreme	No	Yes	Yes	Severe
334.	Less	Yes	No	Normal	No	Extreme	Yes	Yes	Yes	Moderate
410.	Less	Yes	No	Severe	Yes	Extreme	No	Yes	Yes	Severe
467.	Less	Yes	Yes	Normal	No	Less	Yes	No	No	Moderate
506.	Less	Yes	Yes	High	Yes	Extreme	No	Yes	Yes	Severe
555.	Less	Yes	Yes	Severe	No	No	Yes	No	No	Severe

We insert the values of various inputs presented into the rule base under the view rule editor and the computed outputs for all the cases are recorded. We employ Matlab Fuzzy Logic Toolbox to generate the inference mechanism of fuzzy sets as shown in "Fig. 9".

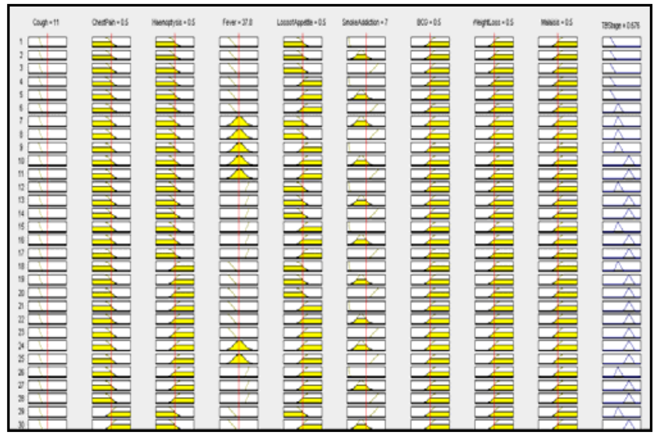
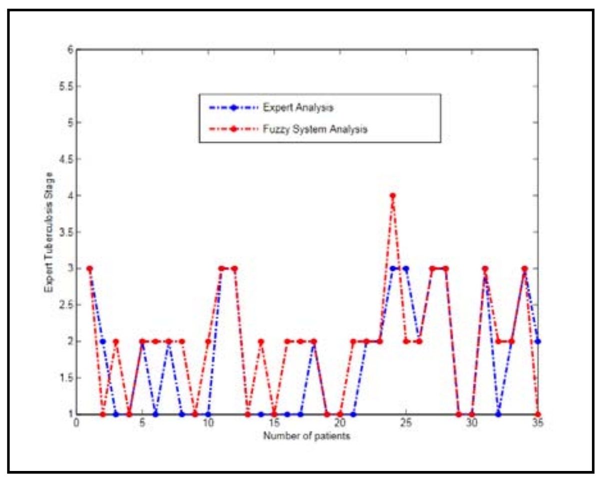


Fig. 9: Graphical Construction of the Inference Mechanism

5. ACCURACY ANALYSIS

In this section, accuracy of system analyzed based on the prescription provided by expert and system generated output. Varying symptoms of 35 patients provided to detect exact possibility of distribution over stage. The fuzzy basis-dependent technique is utilized, which potentially reduces the conservatism of obtained results.



6. CONCLUDING REMARK

In this paper, we have dealt with diagnosis of tuberculosis. We have presented fuzzy diagnosability for tuberculosis and formalize reasoning in rule based system. We have formalized the construction of diagnosers that are used to perform fuzzy diagnosis. In particular, we have proposed a necessary and sufficient condition for diagnosability of bacterium has been given.

Fuzzy logic provides set of techniques which better deal with problems of fuzziness, impreciseness and provides precise results. The newly proposed diagnosability approach helps in decision making of pulmonary physicians in giving the diagnosis. With the results obtained in this paper, a further issue worthy of consideration to other chronic obstructive pulmonary diseases can be done. The designed system can be extended for any number of inputs. Of course, since we have focused only on FIS in this paper, the diagnosis can be done using ANFIS. We would like to consider these issues in subsequent work.

REFERENCES

[1] R. Umi, K. Raja, M. Radzi, W. Mansor, and J. Johari, "Review of Mycobacterium Tuberculosis Detection," pp. 189–192, 2011.

[2] S. Mitra, Y. Hayashi, and S. Member, "Neuro – Fuzzy Rule Generation : Survey in," vol. 11, no. 3, pp. 748–768, 2000.

[3] A. Kaur and A. Kaur, "Comparison of Mamdani-Type and Sugeno-Type Fuzzy Inference Systems for Air Conditioning System," no. 2, pp. 323–325, 2012.

[4] S. J. Mousavi, K. Ponnambalam, and F. Karray, "Inferring operating rules for reservoir operations using fuzzy regression and ANFIS," vol. 158, pp. 1064–1082, 2007.

[5] J. E. Maiers, "FUZZY SET THEORY AND MEDICINE: THE FIRST TWENTY YEARS AND BEYOND Jerald E. Maiers Medical Support Services Inc., Box 5421, Racine, WI 53405," pp. 325–329, 1985.

[6] R. H. Mgaya, C. D. Mccurry, and S. Zein-sabatto, "Intelligent Methodology for Turbine Engine Diagnosis and Health Management," pp. 1–6.

[7] A. Uduak and M. Mfon, "A Proposed Fuzzy Framework for Cholera Diagnosis and Monitoring," vol. 82, no. 17, pp. 1–10, 2013.

[8] K. Soundararajan, "Diagnostics Decision Support System for Tuberculosis using Fuzzy Logic," vol. 2, no. 3, pp. 684–689, 2012.

[9] S. K. Anand, R. Kalpana, S. Vijayalakshmi, S. Hartley, and B. Boucho-meunier, "Design and Implementation of a Fuzzy Expert System for Detecting and Estimating the Level of Asthma and Chronic Obstructive Pulmonary Disease," vol. 23, no. 2, pp. 213–223, 2013.

[10] J. R. Jang, "ANFIS : Adap tive-Ne twork-Based Fuzzy Inference System," vol. 23, no. 3, 1993.

[11] T. Uc, A. Karahoca, and D. Karahoca, "Tuberculosis disease diagnosis by using adaptive neuro fuzzy inference system and rough sets," pp. 471–483, 2013.

[12] X. Y. Djam and Y. H. Kimbi, "A Decision Support System for Tuberculosis Diagnosis .," vol. 12, no. 2, pp. 410–425, 2011.

[13] A. A. Imianvan and J. C. Obi, "Fuzzy Cluster Means Expert System for the Diagnosis of Tuberculosis," vol. 11, no. 6, 2011.

[14] S. Shamshirband, S. Hessam, H. Javidnia, and M. Amiribesheli, "Tuberculosis Disease Diagnosis Using Artificial Immune Recognition System," vol. 11, 2014.

[15] V. C. Osamor, A. A. Azeta, and O. O. Ajulo, "Health Informatics information from the web for use in tuberculosis diagnosis tuberculosis diagnosis," 2014.

[16] K. Adlassnig, "Fuzzy Set Theory in Medical Diagnosis," no. 8406786, pp. 260–265, 1986.

[17] O. Taylan, "Computers & Industrial Engineering An adaptive neuro-fuzzy model for prediction of student ' s academic performance q," vol. 57, pp. 732–741, 2009.

[18] A. R. C. Semogan and B. D. Gerardo, "A Rule-Based Fuzzy Diagnostics Decision Support System for Tuberculosis," 2011.