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Diagnostics Decision Support System for Tuberculosis using Fuzzy Logic

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Abstract— **Healthcare has been one of the top demands of this generation. We present an application of fuzzy logic for the development of decision support system in medicine .Fuzzy logic are a highly suitable and applicable basis for developing knowledge based systems in medicine. This system is mainly specialized for the pulmonary physicians that are focusing on tuberculosis and for patients already diagnosed with tuberculosis. The main focus of this paper is for the development of the system is on the architecture and algorithm used to find the probable class of tuberculosis a patient may have. A Rule–based Fuzzy Diagnostics Decision Support System is used to assign class labels for tuberculosis and fuzzy logic technique is used for class assignment process, Fuzzy rule sets are prepared by doctors. Tuberculosis symptoms and class details are updated in rule based system .Learning and testing operations are performed by this process. The 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.**

Keywords- Fuzzy logic, rule based diagnosis, Decision support system, medical support system, knowledge based systems.

I. INTRODUCTION

In recent years, computational intelligence has been used to solve many complex problems by developing intelligent systems and fuzzy logic has proved to be a wonderful tool for decision making systems, such as expert systems and pattern classification system. Some examples of using fuzzy logic to develop fuzzy intelligent systems are fuzzy systems in their microprocessors ,fuzzy control of the subway system in the Japanese city of Sendai, fuzzy washing machines, fuzzy cameras and camcorders that map image data to lens settings, and fuzzy voice commands: ”up” ,”land” , ”hover” to control an unmanned helicopters. This fuzzy logic concept is a suitable tool for representing and handling medical concepts.

In the present paper, a fuzzy rule based system is designed to serve s a decision support for tuberculosis diagnosis. Pulmonary tuberculosis (TB) is a contagious bacterial infection that involves the lungs, but may spread to other organs. TB is caused by the bacteria Mycobacterium tuberculosis (M. tuberculosis). You can get TB by breathing in air droplets from a cough or sneeze of an infected person. This is called primary TB. In the United States, most people will recover from primary TB infection without further evidence of the disease. The infection may stay inactive (dormant) for years. However, in some people it can reactivate. Breathing difficulty, chest pain, wheezing are the symptoms of tuberculosis.

The scope 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 that 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. Fuzzy logic starts with and builds on a set of user supplied human language rules. The fuzzy systems convert these rules to their mathematical equivalents. This simplifies the job of the system designer and the computer, and results in much more accurate representation of the way systems behave in the real world [1, 2].

In the field of medicine, Imprecision and Uncertainty play a large role in the process of diagnosis of disease that has most frequently been the focus of these applications. With the increased volume of information available to physicians from new medical technologies, the process of classifying different sets of symptoms under a single name and determining the appropriate therapeutic actions become increasingly difficult. A single disease may manifest itself quite differently in different patients at different disease stages. Further, a single symptom may be indicative of several different diseases and the presence of several diseases in a single patient may disrupt the expected symptom pattern of any one of them. Although medical knowledge concerning the symptom – disease relationship constitutes one source of imprecision and uncertainty in the diagnostic process, the knowledge concerning the state of the patient constitute another.

The physician gathers knowledge about the patient from past history, physical examination, laboratory test results and other investigative procedures such as x-ray and ultrasonic. Since the knowledge provided by each of these sources carries with it varying degrees of uncertainty, here we use a fuzzy temporal logic since the state and symptoms of the patient can be known by the physician with only a limited degree of precision. In this paper, we discuss about a medical expert system in which we use fuzzy logic to identify the diseases form the symptoms which helps to develop Fuzzy rules that can be stored in the knowledge base and can be fired during further decision process.

Additional benefits of fuzzy logic include its simplicity and its flexibility. Fuzzy logic can handle problems with imprecise and incomplete data, and it can model nonlinear functions of arbitrary complexity. It not a good plant model, or if the system is changing, the fuzzy will produce a better solution than conventional control techniques, " says Bob Varely, a Senior Systems Engineer at Harris Corp., an aerospace company in Palm Bay, Florida[3].

A fuzzy system can create to match any set of input data. The Fuzzy Logic Toolbox makes this particularly easy by supplying adaptive techniques such as adaptive techniques such as adaptive neuro-fuzzy inference systems (ANFIS) and fuzzy subtractive clustering. Fuzzy logic models, called fuzzy inference systems, consist of a number of confidential "if then" rules. For the designer who understands the systems, these rules are easy to write, and as many rules as necessary can be supplied to describe the system adequately.

In fuzzy logic, unlike standard conditional logic, the truth of any statement is a matter of degree. The inference rule is the form of p - > q. Fuzzy logic is possible to say (.5*p) - > (.5*q). For example, the rule if then, both variables, cold and on, amp to ranges of values [1, 3]. Fuzzy inference systems rely on membership functions to explain to the computer how to calculate the correct value between 0 and 1. The degree to which any fuzzy statement is true is denoted by a value between 0 and 1.Not only do the rule-based approach and flexible membership function scheme make fuzzy systems straightforward to create but they also simplify the design of system.

Rule based method [4, 5] captures knowledge of domain experts into expressions that can be evaluated known as rules. A rule based method makes it easy to store a large amount of information ,and coming help to clarify the logic used in the decision making process, through this rule based method it could demonstrate the magnitude of these types of ailments by comparing the size of the rule base to the narrow scope of the problem space. Through this fuzzy logic, results can be determined therefore there is no void or null results.

In the rest of this paper, we first give some related works in section 2. Then, we introduce the proposed decision support system in section 3. Experimental studies and performance are presented in section 4. This paper is discussed and concluded in sections 5.

II. Review of Related Work

In this section, we will introduce some related works 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.

Shusaku Tsumoto (1999) had proposed a web based medical expert system in which the web server provides an interface between hospital information systems and home doctors. According to them, the recent advances in computer resources have strengthened the performance of decision making process and the implementation of knowledge base (Shusaku Tsumoto 2006) operations. Moreover, the recent advances in web technologies are used in many medical expert systems for providing efficient interface to such systems. Moreover, many such systems are put on the Internet to provide an intelligent decision support in telemedicine and are now being evaluated by regional medical home doctors.

Vladimir Androuchko et al (2006) proposed an expert system called Medoctor, which is a web-based system and has 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 to be economically installed in future versions. The user interface module of that system presents a series of questions in layman's language for knowledge acquisition and also to show the top three possible diseases or conditions. However this system lacks in accuracy in decisions and also it is not following the coding of diseases as per the standards. Hence, there is a need for proposing a system with increased accuracy and standard.

Since 1975, Dr. Edward Shortliffe , Feigenbaum and Buchanan had developed the fist expert system (MYCEN)[6]. Expert system of medicine is became important issue. There are some medical diagnostic systems based on BPN (Back propagation network): "The expert system for dermatology diagnosis" (Yoon et al., 1990) [7], "The diagnosis for acute coronary occlusion" (Baxt, 1990)[8]and "The early diagnosis of heart attacks" (Harrison e tal. , 1991) [9]. 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), "The program of Chinese medical liver complaint diagnosis" (Beijing Chinese medicine hospital) [10].

Soft computing techniques which indicate a number of methodologies used to find approximate solutions are successfully applied in many real-world problems including medical diagnosis problem [11]. Their use in developing disease diagnosis systems are motivated by their ability to handle uncertain information upon which medical diagnosis is usually based [12].Artificial neural networks(ANNs) [13–14] and recently SVMs [14–15] are the most commonly used soft computing methods in developing CHD diagnosis system. Overall, the performances obtained by these systems appear promising as they achieved relatively good classification accuracy, and thus can serve as reliable decision support system for CHD detection. Despite the advantage of being highly accurate, ANNs and SVMs have been criticized due to their lack of transparency as they are black box systems, i. e the user is prevented from knowing about the decision process of their inner systems [16].Transparency or interpretability which refers to the ability of a system to express its behavior in an understandable way, has recently gained more attention and it is considered as an important criterion for medical diagnosis systems [16–17]. Unlike ANNs and SVMs, Fuzzy rule-based systems offer a convenient format for representing the knowledge underlying a system in the form of transparent and linguistic conditional statements. These statements are in the form of "if condition(s) then action(s)" [18]. Such kind of format is humanly understandable as it uses a language close to the natural language which makes it a suitable tool for interpretation and analysis.

In addition, FRBSs use a fuzzy logic-based reasoning scheme to draw conclusions that simulates in some respects the human thinking mechanism [19].Recently, data-driven rule generation methods have dominated the development of fuzzy-based CHD diagnosis systems partly due to the cost and difficulty of manually setting the rules, and partly due to the availability of historical patient data and the recent development of efficient machine learning algorithms.[20–21]. Their only objective is however, getting higher diagnostic accuracy, disregarding the transparency issue. Hence, fuzzy approach adopted by these systems is a kind of black-box system that is used only for calculating rather than inference the diagnosis label. The design of fuzzy rule-based diagnosis system has to consider both the accuracy and the transparency. While the transparency feature is maintained inexpert-driven approach, it is usually lost during the learning process, and to preserve it, many approaches have been proposed [22-23].

Genetic-based approaches are among the most successful ones. Basically, they try to find a fuzzy system that has the required balance between the accuracy and transparency. A Rule–based Fuzzy Diagnostics Decision Support System is used to assign class labels for tuberculosis. Fuzzy logic technique is used for class assignment process. Fuzzy rule sets are prepared by doctors. Fuzzy set analysis is performed to identify classes. The following drawbacks of identified in the existing system.

- Static fuzzy rule base
- Limited accuracy level
- Symptom relationship are not considered

III. PROPOSED DECISION SUPPORT SYSTEM

The system is designed to improve patient diagnosis system. Fuzzy rule base is updated with dynamic rules. The association rule mining methods are used to detect rules. Tuberculosis symptoms and class details are updated in rule base. There are four studies to analyze the effects , they are feasibility study, economic study, operational study and technical study.

The feasibility study is conducted to verify the benefits of the proposed system. The feasibility study also analyzes the requirements of the proposed system. The cost, technology in hardware and software, operational and social impacts is considered in the feasibility study. The economical feasibility is conducted to analyze the cost benefits of the system. The development cost, installation cost, infrastructure cost and operational cost factors are analyzed in the economical feasibility study. The technical feasibility study is carried out to asses the hardware and software technology is required for the system. The hardware requirement and its availability are analyzed in the hardware verification process. The system does not require any additional hardware peripherals to execute the system. The operational feasibility study is conducted to analyze the operational changes between the existing system and the proposed system. The operational change and training details are also analyzed in the operational feasibility analysis.

This proposed rule based Fuzzy Diagnostics is a decision support system that are intended for pulmonary physicians, this will analyze the class of tuberculosis. The system is designed to improve patient diagnosis system. Fuzzy rule base is updated with dynamic rules. Tuberculosis symptoms and class details are updated in rule base.

As the patient must have a history in tuberculosis, then the system provides Fuzzy logic was 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 in each symptom the patient exhibits .the intensity varies depending on the symptom, then the system will summarize and allocate the class of tuberculosis the patient has.

Algorithm of the system is to develop by using Fuzzy Logic tool, by using this tool; the researchers were able to classify the intensity of each symptom according to its description given by pulmonary physicians interviewed. Some of the symptoms like cough were classified as variety of risk, such as low, moderate and high risks. In the formulation of fuzzy set system, the ranges of scores were classified in each symptom. The values or scores had undergone the process of fuzzification. It is also responsible for the threshold calculations that are needed by system for some reasoning, which re included in fuzzy relations. After processing the calculations, the resultant scores were graphed in a symmetrical manner. The graph will illustrate the scores and its corresponding membership values.

After the graph process, the fuzzy logic sets are intersected and it is determined the matrix format. The matrix illustrates the symptoms are between the intersection points. The rules are determined by the scores had undergone defuzzification process. After defuzzification process, the scores were subjected for the development of rules in proposed systems.

IV. EXPERIMENTAL RESULTS

Rule- based method was used to determine the class of tuberculosis, populated by rules made for different classifications of tuberculosis. 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. The values that undergone defuzzification were used to formulate the rules that correspond to the different conditions determined by the matrix.

TB Main Rules

If (condition A = "low risk") && (condition B = "low risk") && (condition C = "low risk") && (condition D = "low") && (condition E = "low risk") then TB is PTB1.

Else if (condition A = "low risk") && (condition B ="Moderate risk")&& (condition C = "low risk") &&(condition D = "low") && (condition E = "low risk") then TB is PTB2.

else if (condition A = "high risk") && (condition B ="moderate risk")&& (condition C = "high risk") &&(condition D = "severe") && (condition E = "high risk")then TB is PTB3.

Else if (condition A = "moderate risk") && (condition B ="moderate risk") && (condition C = "low risk") &&(condition D = "low") && (condition E = "low risk") then is PTB4.

else if (condition A = "moderate risk") && (condition B ="high risk") && (condition C = "high risk") && (condition D = "severe")&& (condition E = "high risk") then TB is PTB5.

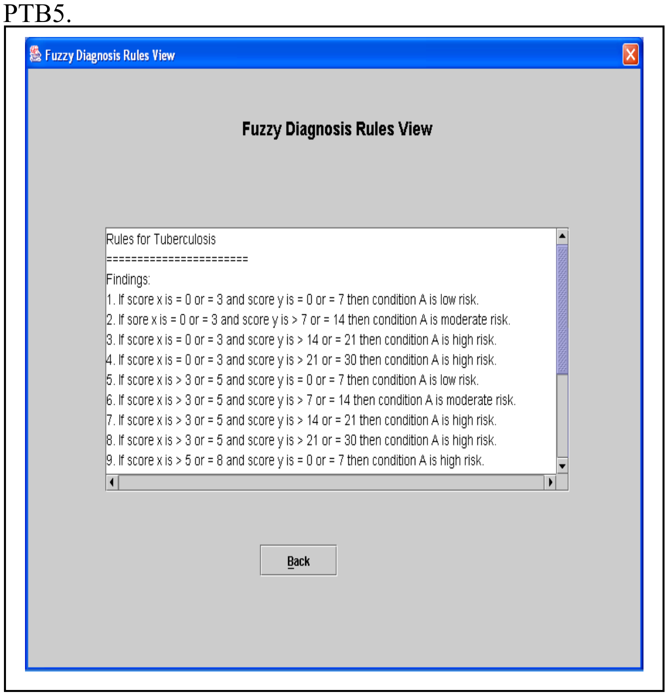

Figure 1 Fuzzy Diagnosis rules view

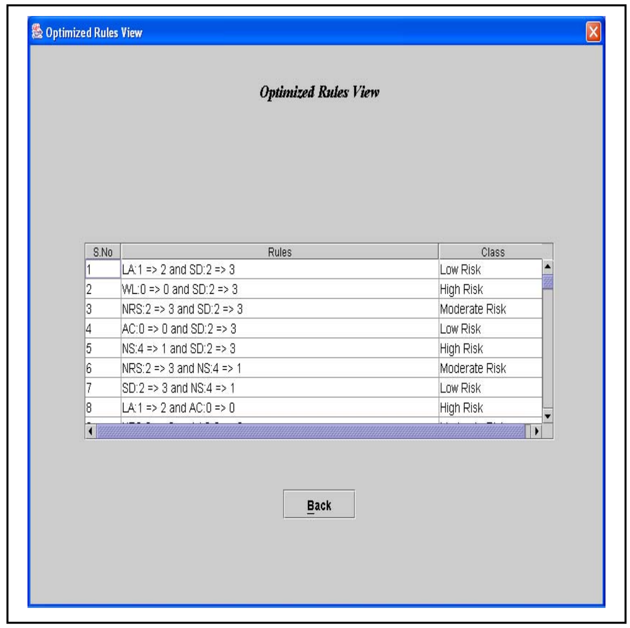

Figure 2 Optimized rules view

The proposed system requires the physician to input all necessary scores of symptoms needed in order to meet the system's purpose. System inputs and symptom scores with corresponding levels of intensity are as follows: cough (0-10), cough duration (0-30 days), body temperature (33-45),fever duration (0-30 days), sputum discoloration (0-10),nose sputum (0-10), afternoon chills (0-10), night sweats (0-10), weight loss (020 kgs), and loss of appetite (0-10)

This sample rule for condition A (cough & cough duration) states that "If score x is ≥ 0 or ≤ 3 and score y is ≥ 0 or ≤ 7 then condition A is low risk". In the classification of tuberculosis, a sample rule states that "If (condition A = "low risk") && (condition B = "low risk") && (condition C = "low risk") && (condition D = "low") && (condition E = "low risk") then is PTB1.

Using fuzzy logic the researchers had come up with 16rules for conditions A to E (the intersection of two interrelated symptoms), and 323 sets of rules (combination of 5 conditions) for the determination of the class of tuberculosis that the patient has. Below is a sample illustration of a Cough and Cough Duration for Condition A:

1. If score x is ≥ 0 or ≤ 3 and score y is ≥ 0 or ≤ 7 then condition A is low risk.
2. If sore x is ≥ 0 or ≤ 3 and score y is > 7 or ≤ 14 then condition A is moderate risk.
3. If score x is ≥ 0 or ≤ 3 and score y is > 14 or ≤ 21 then condition A is high risk.
4. If score x is ≥ 0 or ≤ 3 and score y is > 21 or ≤ 30 then condition A is high risk.
5. If score x is > 3 or ≤ 5 and score y is ≥ 0 or ≤ 7 then condition A is low risk.
6. If score x is > 3 or ≤ 5 and score y is > 7 or ≤ 14 then condition A is moderate risk.

7. If score x is > 3 or ≤ 5 and score y is > 14 or ≤ 21 then condition A is high risk.
8. If score x is > 3 or ≤ 5 and score y is > 21 or ≤ 30 then condition A is high risk.
9. If score x is > 5 or ≤ 8 and score y is ≥ 0 or ≤ 7 then condition A is high risk.
10. If score x is > 5 or ≤ 8 and score y is > 7 or ≤ 14 then condition A is high risk.
11. If score x is > 5 or ≤ 8 and score y is > 14 or ≤ 21 then condition A is high risk.
12. If score x is > 5 or ≤ 8 and score y is > 21 or ≤ 30 then condition A is high risk.
13. If score x is > 8 or ≤ 10 and score y is ≥ 0 or ≤ 7 then condition A is high risk.
14. If score x is > 8 or ≤ 10 and score y is > 7 or ≤ 14 then condition A is high risk.
15. If score x is > 8 or ≤ 10 and score y is > 14 or ≤ 21 then condition A is high risk.
16. If score x is > 8 or ≤ 10 and score y is > 21 or ≤ 30 then condition A is high risk.

V. CONCLUSIONS AND FUTURE ENCHANCEMENT

We have to spend more time on this study to archive our objective that is to formalize medical entities as fuzzy sets, and formalize reasoning in rule based systems in medicine; we have tried distinguishing the notion of "fuzzy logic" in the broad and narrow sense. In this paper, we use "fuzzy logic" in the broad sense to formalize approximate reasoning in medical diagnostic systems. Fuzzy Logic provides a set of techniques which generates reliable and precise results. It greatly helps in the decision making of the pulmonary physicians in giving the diagnosis. This system would aid in the diagnosis of the different classes of tuberculosis. The great advent of technology provides greater opportunities for medical institutions and healthcare. Rule based method and the clinical decision support system that are integrated with fuzzy logic that generates the classes of tuberculosis suits the needs of lessens the time consumed and pulmonary physicians in the generation of diagnosis.

Our further work is to apply the researchers could magnify the features and make the system more usable and marketable by adding set of Diseases with corresponding treatments the system can diagnose. It is also best for the system to have a database in Storing patient information, current medical records and history for future usage and references.

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