Diagnosis of Pulmonary Tuberculosis using Fuzzy Inference System

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Abstract: ***Artificial intelligence is a set of real time computational methodologies to address complex real-world problems. In this paper, Neurofuzzy Inference System for analysis of pulmonary tuberculosis (TB)disease is discussed. For effective result, simulation is being done by using the realistic causes of pulmonary TB. The Neurofuzzy system is used for decision making based on a predefined rule based upon the symptoms of the patient are taken as inputs and the corresponding TB risk quotient is evaluated as the output. This crisp result obtained allows us to diagnose the low or high risk of the disease in the patient. Hybrid learning algorithm is applied for minimization of error in the output.***

Keywords: Artificial Intelligence, Neuro Fuzzy system, Hybrid learning algorithm, Pulmonary Tuberculosis Disease.

I. INTRODUCTION

As concern about rural areas or villages, some time patients hardly get any medical assistance. Online diagnosis of some chronic diseases is increasingly becoming popular day by day. The paper thus proposes intelligence based virtual doctor that uses the service of online diagnostic system [1] for the people to get an easy check up and analysis report based on the individual medical condition. According to the report patient may consult the specialist doctor. The spine of this system is the "knowledge base" which is indeed a well-organized collection of conventional data base with simple if-then rules and practices prevalent in that perspective. Diagnosis and treatment of Tuberculosis, a painful communicable disease, will be focused using artificial intelligence approach.

The word "tuberculosis" was coined by Johann Lukas Schonle in 1839, from the Latin "tuberculum," meaning "small, swelling bump or pimple". Tuberculosis (TB) is an infectious disease caused by mycobacteria, mainly *Mycobacteriumtuberculosis*. Pulmonary Tuberculosis (TB) occurs when an already contagious patient coughs, spreading bacilli through the air. Bovine TB (caused by M. *bovis*) can be transmitted by consuming any unpasteurized dairy product from infected cattle. Tuberculosis is closely linked to both overcrowding and malnutrition. Those at high risk include: people who inject illicit drugs, inhabitants and employees of locales where vulnerable people gather (e.g. prisons and homeless shelters).The chronic type that we are dealing with, is Pulmonary Tuberculosis. It is substantially a deadly disease, but now–a-days it is curable if we get medical help timely and follow the doctor's recommendations. It usually affects the lungs, but can also affect other parts of the body. There are more than eight million cases of people contracting TB every year across the globe, with about two million people per year dying from this disease.

Medically, multi-drug treatment is engrossed to treat active TB disease. Many reports are presented on MDR in context with tuberculosis [9-12]. Depending on state or local public health regulations, you may be asked to take your antibiotics under the supervision of your physician. This program is called "Directly Observed Therapy" and is the one commonly used. A rule based system is created for the diagnosis of epidemic diseases comprising of knowledge reservoir of practitioners [2]. From past few decades, tuberculosis control campaigns have been running in India. The World Health Organization (WHO) also involves in Revised National Tuberculosis Control Program. A study revealed that computer aided diagnostic system using fuzzy logic is less accurate but efficient [3] and [4]. Along with this, a Fuzzy Cognitive Map (FCM) is used for the decision making process [5-8]. The Research of the proposed work as follows; section II presents Neuro fuzzy diagnostic intelligence system for pulmonary tuberculosis; section III illustrates simulated results of Adaptive Neuro fuzzy System (ANFIS) for tuberculosis and in the end section IV summarizes the conclusions and scope for future research.

II. NEURO FUZZY DIAGONISTIC INTELLIGENCE SYSTEM FOR PULOMONARY TUBERCULOSIS

The proposed Medical Diagnostic System (MDS) is meant to diagnose various diseases in an expert system. Fuzzy logic is one of the most efficient qualitative computational methods initially advanced by Dr. Lotfi Zadeh of the University of California at Berkeley in the 1960s. It is an approach to computing based on "degrees of truth" i.e. membership rather than the usual

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"true or false" (1 or 0) Boolean logic on which the modern computer is based.

An Adaptive Neurofuzzy Inference System (ANFIS) is an Artificial Neural Network (ANN) approach that is functionally equivalent to a first-order Sugeno-style Fuzzy Inference System (FIS). There are six layers in an ANFIS model; one input layer, four hidden layers, and one output layer. Each layer performs a particular task to forward the signals. Such an ANFIS model is shown in Figure: 1.

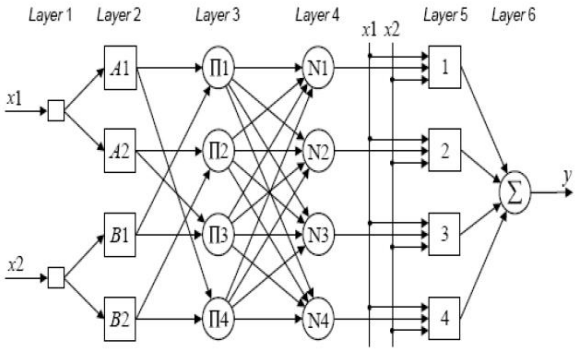

Figure 1: Six layer model of ANFIS System[15]

The adaptive fuzzy rule based system is used for the diagnosis of Tuberculosis efficiently [14] and [15].The technique was developed in the early 1990s. Based on the selection of the problem area, the expert system is established on certain defined inputs as per the symptoms of patients suspected of pulmonary TB. The fuzzy based virtual doctor analysis the data and using the Sugeno model of ANFIS. The fuzzy expert system diagnosis disease based on its knowledge reservoir and gives the result in fuzzy form. The process of conversion of scalar inputs into fuzzy values is called fuzzification. From different types of fuzzifiers such as triangular, Gaussian, trapezoidal singleton etc. [13], Gaussian fuzzifier is made use of, to create an intelligence system in consultation with experts for the analysis purpose.

An architecture of tuberculosis is proposed based on the information collected on the disease. There are various parameters which are responsible for Tuberculosis. Figure 2 shows the diagrammatical representation of TB symptoms taken as inputs and their linkage with the ANFIS Sugeno model that produces the analytical risk quotient as output.

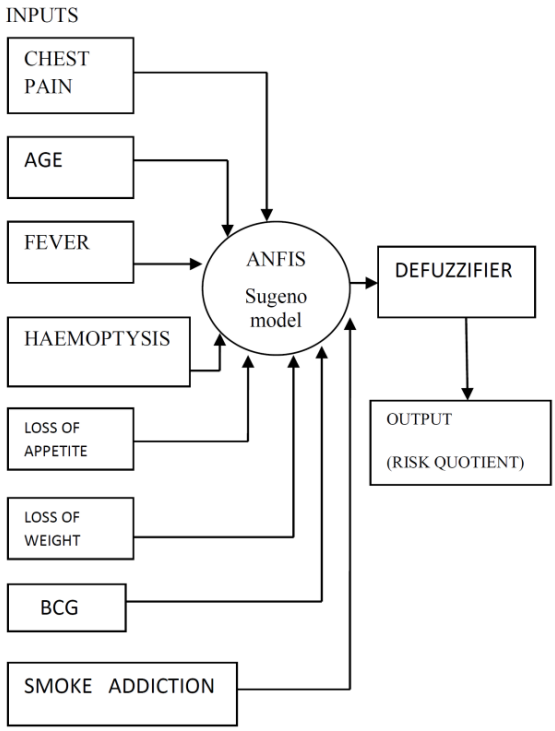

Figure 2: Diagrammatic representation of ANFIS model

Based on the above parameters using Sugeno model, we designed certain predefined rules for the knowledge based fuzzy inference system for analysing the risk of tuberculosis in the patient. Following are some rules summed up:

- If Prolonged cough=mild and Anorexia=mild and Haemoptysis and sputum=mild and weight loss= mild and low grade fever= mild, the risk quotient=no risk
- If Prolonged cough=mild and Anorexia=moderate and Haemoptysis and sputum=mild and weight loss= moderate and low grade fever= moderate, the risk quotient=low
- If Prolonged cough=moderate and Anorexia=moderate and Haemoptysis and sputum=severe and weight loss= moderate and low grade fever= severe, the risk quotient=high
- If Prolonged cough=severe and Anorexia=severe and Haemoptysis and sputum=severe and weight loss= mild and low grade fever= moderate, the risk quotient=high
- If Prolonged cough=severe and Anorexia=severe and Haemoptysis and sputum=severe and weight
- loss= moderate and low grade fever= severe, the risk quotient=high
- If Prolonged cough=severe and Anorexia=mild and Haemoptysis and sputum=mild and weight loss= mild and low grade fever= mild, the risk quotient=low
- If Prolonged cough=severe and Anorexia=moderate and Haemoptysis and sputum=mild and weight loss= moderate and low grade fever= mild, the risk quotient=low

- If Prolonged cough=mild and Anorexia=moderate and Haemoptysis and sputum=severe and weight loss= severe and low grade fever= moderate, the risk quotient=high
- If Prolonged cough=severe and Anorexia=mild and Haemoptysis and sputum=severe and weight loss= severe and low grade fever= severe, the risk quotient=high
- If Prolonged cough=mild and Anorexia=moderate and Haemoptysis and sputum=mild and weight loss= mild and low grade fever= mild, the risk quotient=no risk

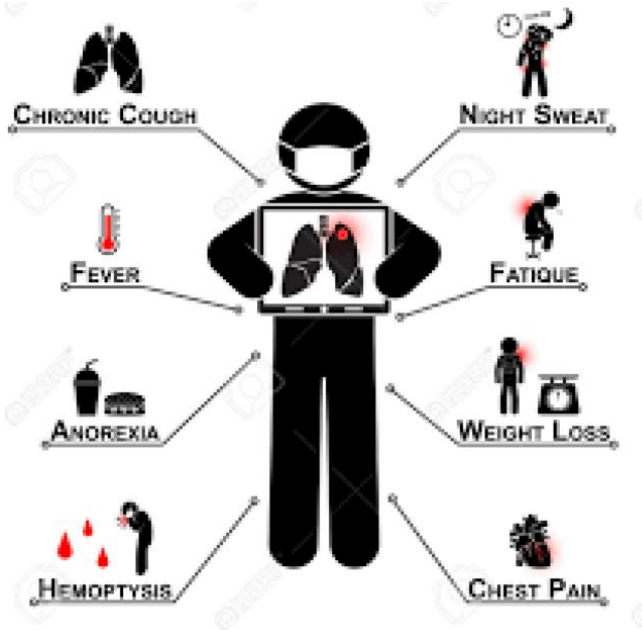

Figure 3:Visible Symptoms of Pulmonary TB

The flowchart of the proposed system is depicted in figure4.The fuzzy logic classifier variables i.e. symptoms of the patient are first received as inputs . Membership functions are then defined using the selected range of inputs. These functions are of Gaussian type. Based on the inputs a fuzzy rule base is created whose combined work process can be viewed from the Matlab Fuzzy Ruler Viewer. Thereafter the surface plot of the system is viewed using surface viewer. Now a program file is created to load data for training and testing purpose against a fixed tolerance. If the tolerance is more than error, then rules are modified and the above steps are repeated. Now finally the neural fuzzy structure of the system is obtained.

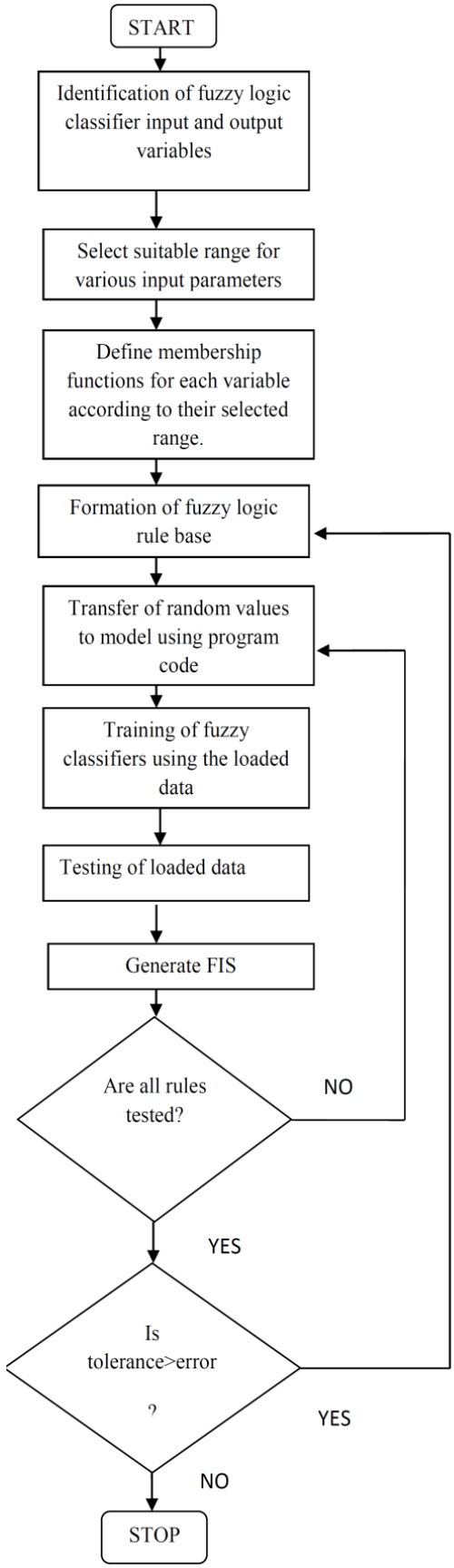

Figure 4:Flowchart of the proposed system

III. SIMULATION BASED RESULTS AND DISCUSSION

A. Fuzzy Inference System using sugeno model:

A Sugeno model is developed in Fuzzy Inference System by defining prolonged cough, anorexia, haemoptysis & sputum, unintentional weight loss and low grade fever as system inputs and the risk quotient as output as shown in figure 5.

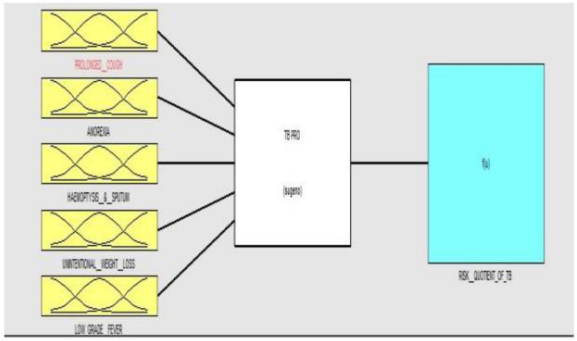

Figure 5:Sugeno model showing the inputs and output

B. Membership function plot:

The potential symptoms are taken as input and membership functions are defined according to the suitable ranges thus defining the level of severity (mild, moderate, high) of the disease as shown in figure 6.

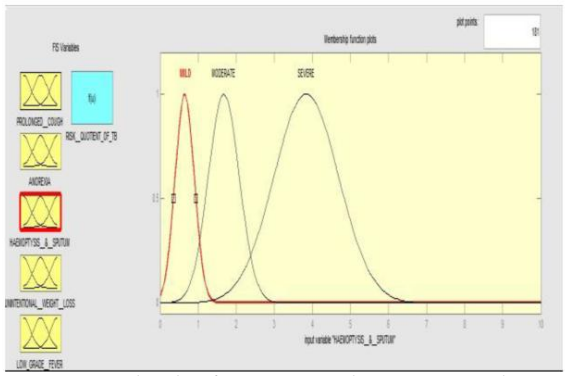

Figure 6:Membership functions correlating inputs with output

C. Rule Viewer for Pulmonary TB :

On the basis of the if-then rules defined, a set of values are obtained and processed using rule viewer. The Rule Viewer presents the on sight view of the fuzzy inference system's process. The Rule Viewer also depicts how the shape of certain membership functions influences the final result. Each rule is a row of plots, and each column is a variable.T he system has a single output (risk quotient), obtained using weighted average defuzzification process. All output membership functions should be of similar type whether linear or a constant. In this research paper, constant type membership functions are used as shown in figure 7.

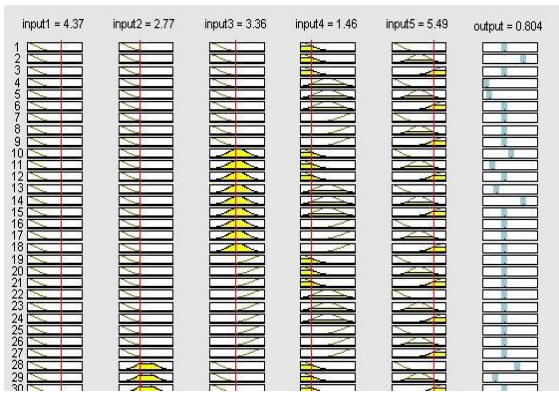

Figure 7:Fuzzy rule base of the proposed work

D. NFIS Training and Testing performance

70% of the processed data is used for training while 30% of the same data is utilised for testing purpose using Hybrid algorithm. Here '°'represents training data while '.' represents testing data as shown in figure 8.

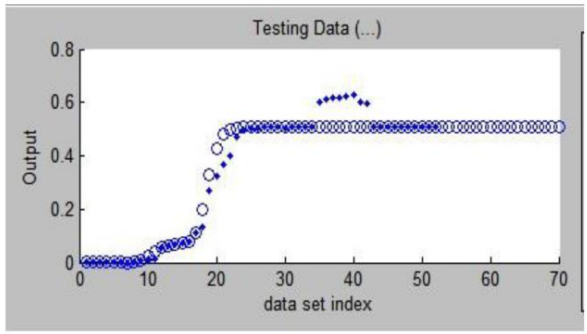

Figure 8:Training and testing plot

E. Error during Training and Testing of data:

During the training process , hybrid algorithm is used for the reduction of error of the system.The experiment was carried out with 100 sample data for comparing the neural network learning Algorithms. After the complete process Error came out to be 0.00774 as shown in Figure 9.

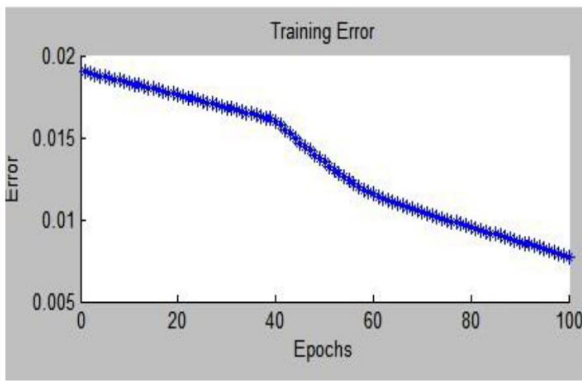

Figure 9: Error plot(0.00774)

F. Surface Viewer for Pulmonary TB:

After training and testing of the processed data, a 3-D surface plot is obtained as shown in Figure 10 with any two input variables on the horizontal & vertical axis and the output variable on the third axis. The surface viewer provides the facility of examining it at different angles for any further corrections.

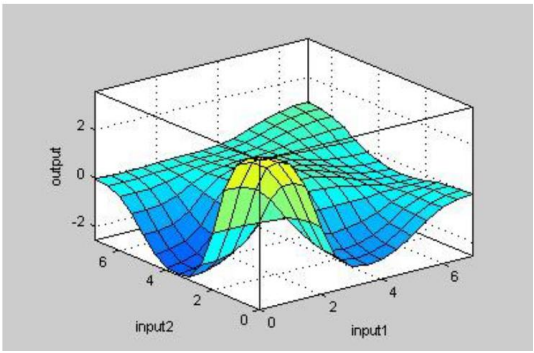

Figure 10: Surface plot of the system

G. Neuro fuzzy Inference system model:

After the training of the system is completed using NFIS, the final neuro-fuzzy inference system model is obtained as shown in figure 11, indicating the five inputs and aoutput as per their different combinations.

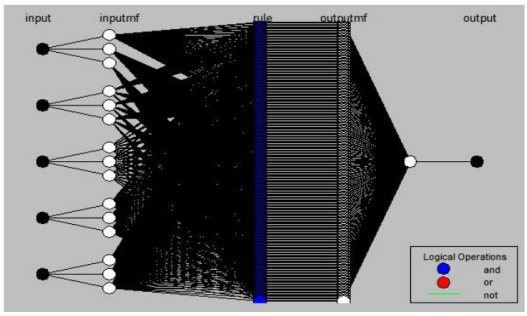

Figure 11: Neurofuzzy structure of Tuberculosis

IV. CONCLUSION

In this paper, we have presented a Neuro-fuzzy intelligence system for detection of the disease Tuberculosis. A decision making system based on the set of rules is basic outline of this research. The research work demonstrates therisk quotient of TB and its severity based on various parameters as inputs that are consultedwith physicians as shown in figure 2.Further, the accuracy of system is calculated and itcame out to be 92%. This system would aid in the diagnosis of the different levels of tuberculosis.The proposed research has wide application in different fields like neural sciences, image filtering, performance analysis of dynamical systems etc. Along with this, it plays an important role in Rural areas,for helping out people suffering from the disease due to less availability of a doctor.This research work is under consideration for the preliminary diagnosis of Tuberculosis.

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