NEURO-FUZZY APPROACH FOR DIAGNOSING AND CONTROL OF TUBERCULOSIS

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ABSTRACT

Tuberculosis is the second leading cause of death from an infectious disease worldwide, after the human immunodeficiency virus. The main aim of this research work is to develop a Neuro-Fuzzy system for diagnosing tuberculosis. The system is structured with to accept symptoms with the help of three domain Medical expertise as inputs that are used to automatically generate rules that are injected in to the knowledge based where the system would use to make decisions and draw a conclusion. MATLAB 7.0 is used to implement this experiment using fuzzy logic and Neural Network toolbox. In this experiment linguistic variables are evaluated using Gaussian membership function. This system will offer potential assistance to medical practitioners and healthcare sector in making prompt decision during the diagnosis of tuberculosis. In this work basic emblematic approach using Neuro-fuzzy methodology is presented that describes a technique to forecast the existence of mycobacterium and provides support platform to researchers in the related field.

KEYWORDS

Tuberculosis, Neuro-fuzzy, Fuzzy logic, Artificial Neural Network, Diagnosing, Mycobacterium

1. INTRODUCTION

Tuberculosis was discovered by German Physician Robert Koch in 1882. Tuberculosis (TB) is caused by a bacterium called Mycobacterium tuberculosis. Pulmonary tuberculosis is a contagious bacterial infection that involves lungs, but may spread to other organs Navneet, *et al.,* (2015). Tuberculosis is the second leading cause of death from an infectious disease worldwide, after the human immunodeficiency virus Mahmoud, *et al.,*(2015).Basically there are two types of tuberculosis infection: latent and active Tuberculosis. In Latent TB, bacteria remain in the body but in an inactive state. Even though cause no symptoms and is not contagious, but they can become active. While Active TB has symptoms and can be transmitted to others, about one-third of the world's population is believed to have latent TB. There is a 10% chance of latent TB becoming active, but this risk is much higher in people who have compromised immune systems that is people living with Human Immune Virus (HIV) or malnutrition, or people who smoke According to James, (2017).The Typical outward indications of pulmonary tuberculosis include persistent cough for two weeks or more and usually accompanied by any of the following symptoms coughing with blood, night sweats, difficulty in breathing, fever, loss of appetite and tiredness Karahoca, and Karahoca, (2013).

In the context of Medicine, diagnostic decision of disease depends on the experiences and expertise of the medical doctor in relation to the symptoms of the disease. In this infectious disease, the microorganisms frequently penetrate into the lungs through breathing and are spread to the whole body through the blood circulatory system, which is direct extension to other organs. Shahaboddin *et al.,* (2014) Tuberculosis is usually transmitted and spread via aerosols (droplets from the mouth and respiratory tract) that are coughed, sneezed, or forcibly expelled from the body to the surrounding air. These droplets, when inhaled by a susceptible host, can infect a new person and, within weeks to months, the disease begins to develop in that infected person (Imianvan & Obi, 2011). The constant communications between medical practitioners, computer scientists, computer engineers and electronic engineers have led to the development of expert system that would diagnosis a patient. Many techniques has been used to build such system but fuzzy logic, neural network, genetic algorithm and swarm intelligence were the most commonly used in the literatures as stated in (Smita, *et al.,* 2013) “The Fuzzy Expert System has proved its usefulness significantly in the medical diagnosis for the quantitative analysis and qualitative evaluation of medical data, consequently achieving the correctness of results.”

Fuzzy logic is an artificial intelligence technique that handles numeric data and linguistic knowledge simultaneously; it is a non-linear mapping of inputs (vectors) to an output (scalar) i.e. it maps numeric value to numeric values. Fuzzy logic presents an inference morphology that enables appropriate human reasoning capabilities to be applied to knowledge-based systems. The theory of fuzzy logic encompasses a mathematical strength to capture the uncertainties associated with human cognitive processes (Imianvan& Obi, 2011).

The hybridization of fuzzy logic and Neural Network resulted to Neuro-fuzzy system models (Jang*et al.,* 1997). The integration of biological science, Artificial intelligence (AI), and mathematical models have entered a period of rapid discovery in medicine and are used to assist physicians to more accurately diagnose various diseases Polat*et al.* (2007).

Despite the advancements in Tuberculosis treatment, early diagnosis is still very important for increasing the survival rates of Tuberculosis patients. The most common standard of diagnosing Tuberculosis is cultured specimens however, results take weeks to obtain. These slow and insensitive diagnostic methods hampered the global control of tuberculosis, and scientists are looking for early and accurate detection strategies, which remain the foundation of tuberculosis control. This research work is to develop a Neuro-Fuzzy system for diagnosing tuberculosis through a comprehensive survey on research contributions that investigates the utilization of Neuro-fuzzy in diagnosing and to provide a roadmap on building the model that would ease and fastened the diagnosing of tuberculosis and its control.

2. Artificial Intelligence / Computational Intelligence Applied To Medical Diagnosis

Prinhatini and Putra, (2012) Developed knowledge-based Expert system for diagnosing tropical infectious diseases on web based platform to receive input in the form of physical symptoms and results of complete blood examination in the laboratory. The inputs are crisp and fuzzy value to handle the vagueness of symptoms. Fuzzy rules represent the correlation of symptoms of each disease using the certainty of the expert. The system provides output from the diagnosis of the seven existing disease expressed as a percentage of certainty of the user experience of the disease. They tested results show that the system developed has the similarity with the real expert at 91.07%.

Jahantigh, (2015) Presented a kidney diseases Diagnosis system using fuzzy logic the results of the research indicated that, in the diagnosis of eight cases of kidney diseases through the examination of 21 indicators using fuzzy logic, kidney stone disease with 63% certainty was at the first level and renal tubular with 15% was at the lowest level and the other kidney diseases were at the other levels.

Egwali and Obi, (2014) developed an adaptive Neuro-Fuzzy Inference System for Diagnosis of Ebola Haemorrhagic Fever (EHF) Five ANFIS classifiers were used to detect five EHF state using 34 clinical symptoms (parameters) and five EHF risk level as inputs to the system. The paper presents by (Nawarycz and Pytel, 2013) fuzzy Abdominal Obesity (AO) models were developed on the basis of Body Mass Index, Waist Circumference and Weight to Height ratio measurements. Fuzzy logic based system for the classification of seven types of neuromuscular diseases at first level and classification of eight types of muscular dystrophy diseases at second level presented in Pandey and Heena, (2014). Fuzzy C-means and probability-based classification was presented in Yun and Lin, (2008) to classify the severity of depression. In their work scoring of beck depression inventory of subjects were analyzed by clustering analysis while the diagnose of depression-severity by a psychiatrist was used as the criterion to evaluate classification accuracy. While (Patil and Mohsin, 2013,Shahaboddin et al. 2014and Valley and Sarma, 2015) discussed fuzzy logic for health status based on bio-signal reading, artificial immune recognition system with fuzzy used for identification of tuberculosis and using hybrid system to diagnose chest diseases respectively.

3. MATERIALS AND METHODS

This research work derived the concept of Expert system of forward or backward chaining. In forward chaining the system reason from antecedent truth to consequent truth, that is, the system would draw a conclusion from the facts in the rule antecedent and establish new facts. The system is structured with eleven (11) inputs and one output of which one hundred and twenty (120) rules were generated. A domain Medical expertise definitions are injected in to the knowledge based where the system would use to make conclusive decisions. MATLAB 7.0 Fuzzy and Neural toolboxes are used to implement this research.

3.1. Data Collection and Analysis

The symptoms of Tuberculosis were analyzed based on the information gathered from Experts. The likely symptoms were used as inputs of the system. The inputs are; persistent cough of two (2) weeks or more, coughing with blood, weight loss, tiredness, fever, night sweat, chest pain, difficulty in breathing, loss of appetite, lymph node enlargement and history of positive TB contact.

The inputs parameters are based on patient demographic data and clinical findings obtained during the interviewed. **Persistent cough** parameter is define based on four (4) linguistic variables one (1) week, two (2) weeks, three (3) weeks and four (4) weeks, cough with blood,Weight loss, Night sweat, difficulty in breathing, loss of appetite, lymph node enlargement and History of positive TBcontact are defined based on two linguistic variables which are presence and absence. **Tiredness** are define based on two (2) linguistic variables which are Yes and No,**Fever** parameter are define based on four (4) linguistic variables which are Mild, Moderate, Severe and very severe, **Chest pain** parameter is define based on four (4) linguistic variables which are Mild, Moderate, Severe and very severe.

3.2. Neuro-Fuzzy Tuberculosis Model

The figure below shows the actual system architecture with the inputs representing the eleven symptoms which are: persistent cough for two weeks or more, coughing with blood, weight loss, tiredness, fever, night sweat, chest pain, difficulty in breathing, loss of appetite, lymph node enlargement and history of positive TB contact. The input mf represents the Inputs membership functions which are Presence and Absence, Mild, Moderate, Severe, Very severe, Yes and No. The rule represent the (120) rules generated by the system, the output mf represent the output membership functions which are Pulmonary Tuberculosis and No TB while the Y block represents the output. The output of this model is based on the mapping between the inputs and outputs membership functions generated by the Neuro-fuzzy system produce the final output (Y).

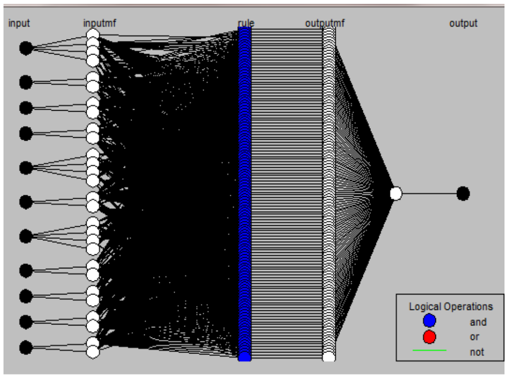

Figure: Neuro-Fuzzy TB model

4. RESULTS AND DISCUSSION

4.1 Inputs Membership Functions

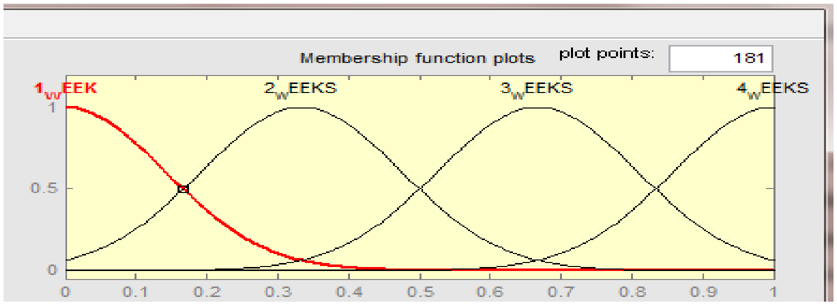

Figure 1: Input Membership Function Plot for Cough

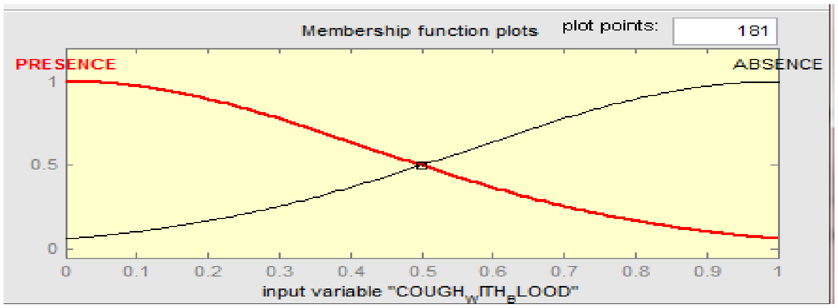

Figure 2: Input Membership Function Plot for Cough with blood

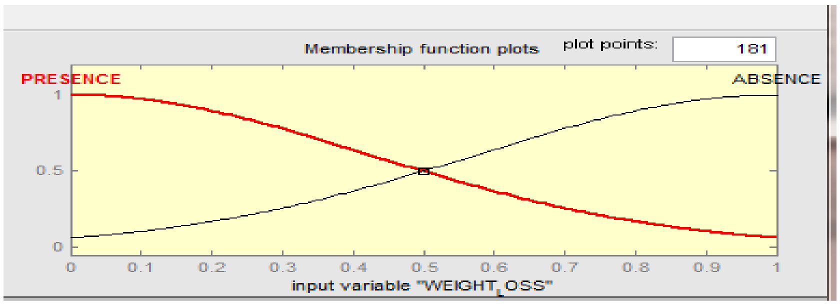

Figure 3: Input Membership Function Plot for weight loss

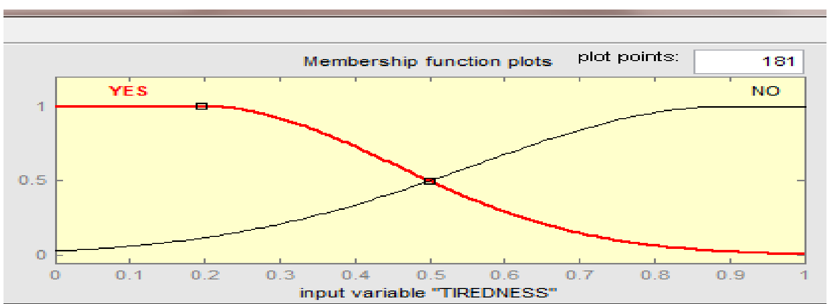

Figure 4: Input Membership Function Plot for Tiredness

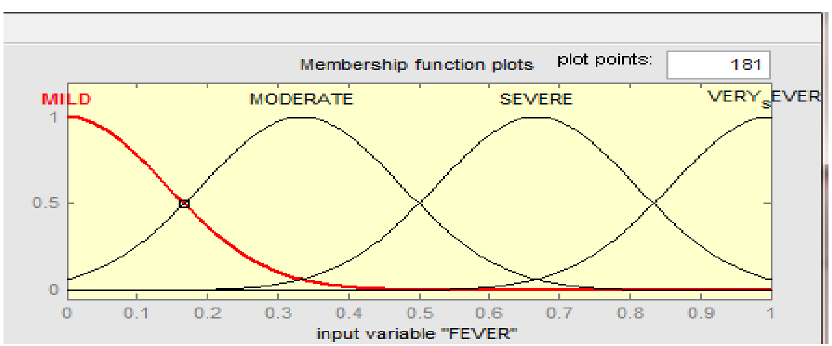

Figure 5: Input Membership function plot for fever

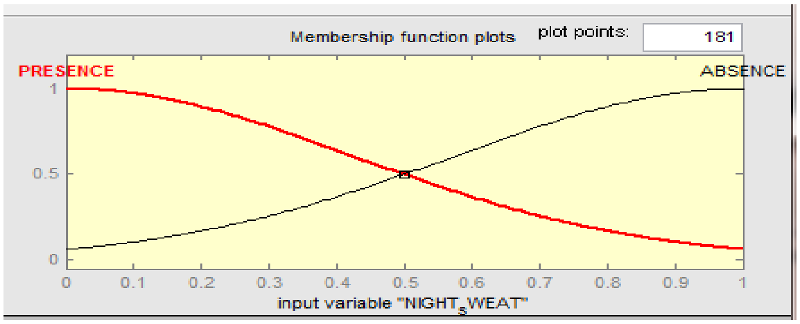

Figure 6: Input Membership Function Plot for Night sweats

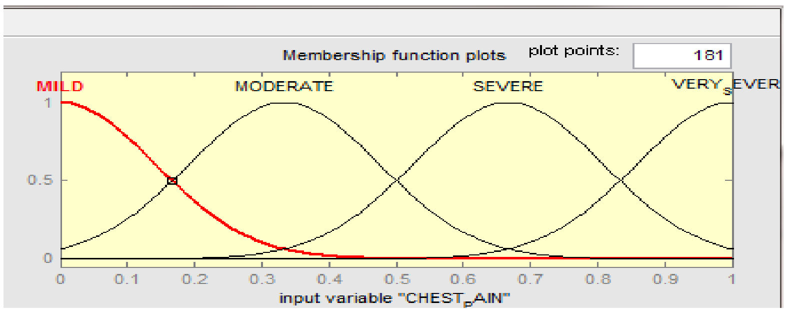

Figure 7: Input Membership Function Plot for chest pain

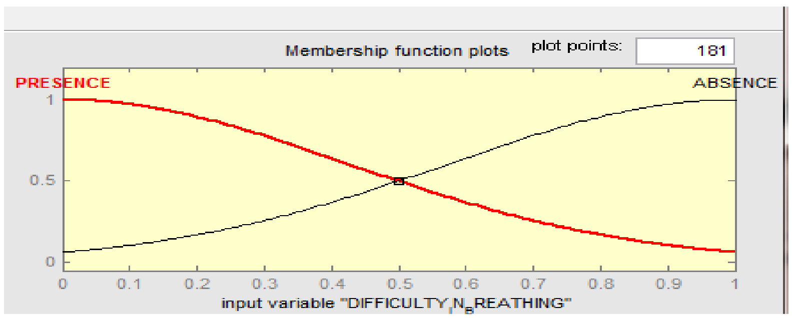

Figure 8: Input Membership Function Plot for Difficulty in breathing

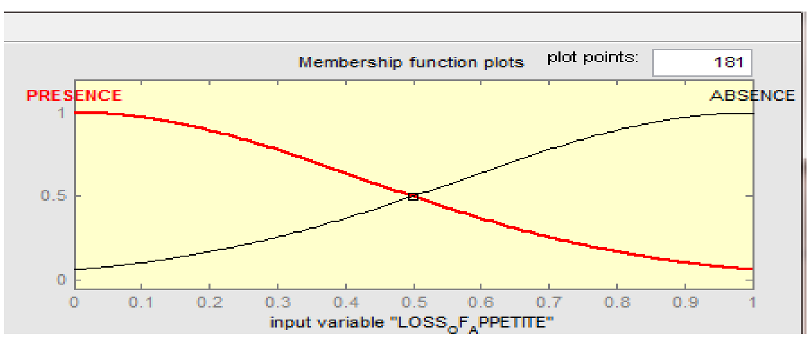

Figure 9: Input Membership Function Plot for loss of appetite

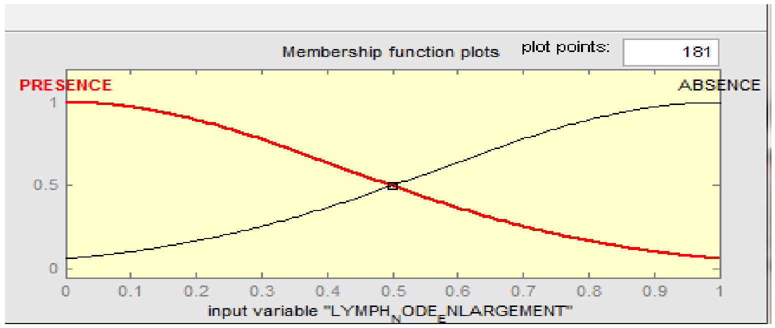

Figure 10: Input Membership Function Plot for Lymph node enlargement

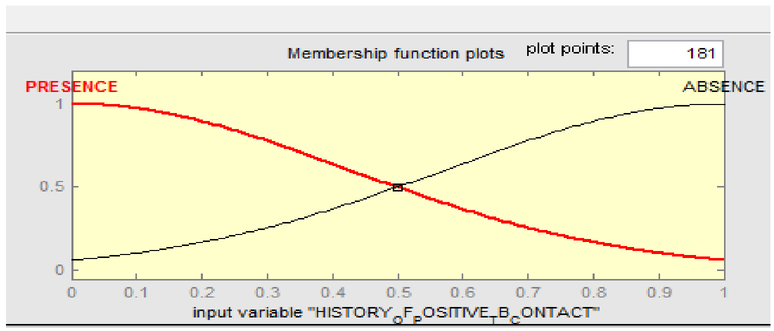

Figure 11: Input Membership Function Plot for history of positive TB contact

4.2 Inputs and TB Range analysis

Based on this work all inputs parameter were given a numeric values depend on the gravity of the input in diagnosing TB.The higher the numeric value given the higher the possibility of TB the lower the number the lower the possibility of TB as shown in the figure 12;

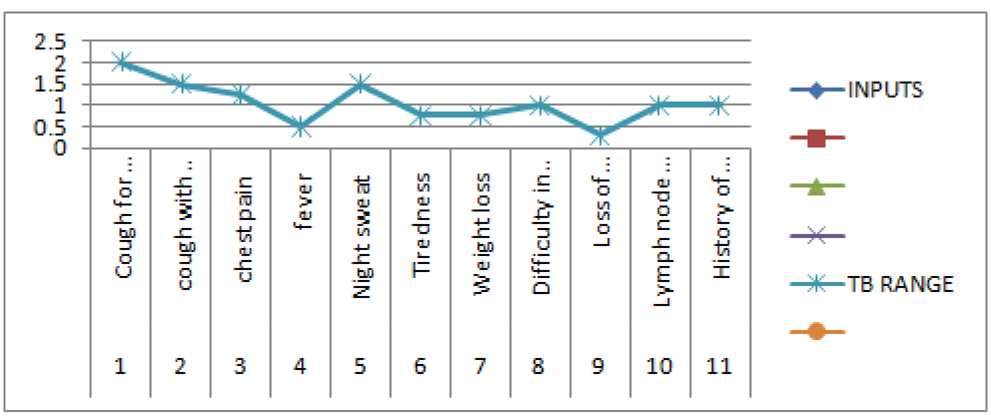

Figure 12: Inputs and output mapping analysis

In this research work Numeric values are assigned to the inputs parameters, the greater the value the higher the possibility of TB and otherwise. Figure 12 above shows that coughing for two weeks or more has the highest value that is 2 which indicated that if the cough exceed two weeks automatically there is highest possibility of TB, coughing with blood and Nightsweat are the second leading symptoms of TB,1.5 is assigned to them which also shows the possibility of TB, chest pain is 1.25, difficulty in breathing lymph node enlargement and history of positive TB contact 1 is assigned to them, tiredness is 0.75, fever is 0.5 and loss of appetite is 0.3 which were used throughout this experiment to draw conclusion whether apatient has TB or not.

4.4 Discussion

The advantage of the fuzzy logic and neural networks lies in their ability to process nonlinear relationships. Because of the clinical complexity and pathologic heterogeneity of TB, correct identification of patients with active disease is likely depends on the presence of a single defining feature. Hence, it is not surprising that standard linear statistical methodologies are relatively inadequate solutions for this type of problem.

The diagnosing tuberculosis system is based on Neuro-Fuzzy approach. It is designed for diagnosis of tuberculosis disease in human. This system consists of 11 input variables as indicated in the figure 12; persistent cough of two (2) weeks or more, coughing with blood, weight loss, tiredness, fever, night sweat, chest pain, and difficulty in breathing, loss of appetite, lymph node enlargement and history of positive TB contact. The rule base of this system consists of 120 rules are used to determine one output parameter: the presence of Pulmonary Tuberculosis. Sugeno inference engine is adopted for this research work. We used center of gravity method for the defuzzification in this research.

5. CONCLUSION

Neuro-Fuzzy Approach to diagnosing tuberculosis was implemented using MATLAB 7.0 Fuzzy Inference System. The system allowed us to clearly see the relationship between various inputs and output based on the rules automatically generated by the Neuro-fuzzy system and this research work can be in cooperated into medical diagnostic machine for TB diagnostic.

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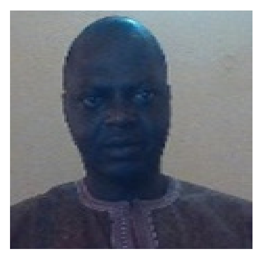

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