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Machine Learning Algorithm Applied for Predicting the Presence of Mycobacterium Tuberculosis

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Abstract: Tuberculosis is a contagious disease that causes of death. The body's response to active TB infection produces inflammation that can damage the lungs. Areas affected by active TB gradually fill with scar tissue. It is spread from person-to-person. A person is often infected by inhaling the germs. Tuberculosis germs are spread into the air when a person with TB disease of the lungs or throat coughs, sneezes, speaks, or sings. These germs can stay in the air for several hours, depending on the environment. However, patients with chronic diseases, such as diabetes, chronic kidney disease, and silicosis, are at elevated risk. Finally, age younger than 4 years, long-term malnutrition, and substance abuse are independent risk factors for disease. The aim of this research work is to develop an adaptive Neuro-Fuzzy system for predicting the presence of Mycobacterium tuberculosis. The system is structured with inputs and one output of which rules were generated by the system with the help of three domain Medical expertise and are injected in to the knowledge based where the system would use this rules to make decisions and draw a conclusion. MATLAB7.0 was used to implement this experiment using fuzzy logic and Neural Network toolbox. In this experiment linguistic variables are evaluated using Gaussian membership function.

Keywords: Mycobacterium, Tuberculosis, Adaptive Neuro-fuzzy, MATLAB

1. Introduction

Fuzzy logic and neural networks are machine learning algorithms that are natural complementary tools in building intelligent systems. While neural networks are low-level computational structures that perform well when dealing with raw data, fuzzy logic deals with reasoning on a higher level, using linguistic information acquired from domain experts. However, fuzzy systems lack the ability to learn and cannot adjust themselves to a new environment. On the other hand, although neural networks can learn, they are opaque to the user. The merger of a neural network with a fuzzy system into one integrated system therefore offers a promising approach to building intelligent systems. Integrated Neuro-fuzzy systems can combine the parallel computation and learning abilities of neural networks with the humanlike knowledge representation and explanation abilities of fuzzy systems. As a result, neural networks become more transparent, while fuzzy systems become capable of learning [1].

A Neuro-fuzzy system is a neural network that is functionally equivalent to a fuzzy inference model. It can be trained to develop IF-THEN fuzzy rules and determine membership functions for input and output variables of the system. Expert knowledge can be easily incorporated into the structure of the Neuro-fuzzy system. At the same time, the connectionist structure avoids fuzzy inference, which entails a substantial computational burden [1].

Tuberculosis is the second leading cause of death from an infectious disease worldwide, after the human immunodeficiency virus [2]. 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 percent 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 or malnutrition, or people who smoke. According to [3]. 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 [4].

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. Consequently, there is a need to develop an expert system that helps medical professionals to have accurate and fastened the diagnosis of Tuberculosis. As the computational intelligence and Artificial intelligence grows day by day, varieties of computational intelligence techniques has been applied to clinical diagnosing which include fuzzy logic, genetic algorithm, swarm intelligence, artificial neural network and Artificial immune system. However in this research we are going to integrate Artificial Neural Network and fuzzy logic that results to Neuro-fuzzy model which eases and fastened the diagnostic method of tuberculosis. The main aim of this research work is to develop a Neuro-Fuzzy system for predicting the presence of mycobacterium tuberculosis with the following objectives; to have a comprehensive survey on research contributions that investigates the utilization of Neuro-fuzzy in diagnosing and to provide a roadmap on building the system architecture that would ease and fastened the diagnosing of tuberculosis.

2. Machine Learning Algorithm Applied to Medical Diagnosis

Decision support system which predicts the possibility of heart disease risk of patients for the next ten-years using fuzzy logic and decision tree was developed by [5]. [6] developed a medical diagnostic system using Visual Prolog Programming language. Their system proffers solution to the enormous responsibilities of the diagnostic process carried out by medical personnel using fuzzy logic [5].

Expert system for diagnosis of heart disease by the method of Fuzzy Logic. The system uses eleven inputs and one output. The fuzzy Inference they used is Mamdani and the defuzzification method used is centroid. They tested their results with 303 patients from Cleveland Clinic Foundation showed that success rates of 94% of systems [7, 8] in his work titled “Fuzzy Expert System for Medical Diagnosis” The output of his work is coming out to be more reliable and dependable as they have used the fuzzy approach to diagnose the dengue disease. Till date the best work done in this field was of “A New Intelligence – Based Approach for Computer-Aided. Diagnosis of Dengue Fever” who had work upon probabilistic model to predict the occurrence or the non-occurrence of dengue for a patient based on the symptoms generated, This paper suggests that an almost 100% accurate in predicting the type of dengue fever. As per the actual data matched with the results generated by the training tool, it was found that 95+ % of the results generated by the tool were similar to the actual data of the patients.

3. Adaptive Neuro-fuzzy System

Fuzzy logic and neural networks are natural complementary tools in building intelligent systems. While neural networks are low-level computational structures that perform well when dealing with raw data, fuzzy logic deals with reasoning on a higher level, using linguistic information acquired from domain experts. However, fuzzy systems lack the ability to learn and cannot adjust themselves to a new environment. On the other hand, although neural networks can learn, they are opaque to the user. The merger of a neural network with a fuzzy system into one integrated system therefore offers a promising approach to building intelligent systems. Integrated Neuro-fuzzy systems can combine the parallel computation and learning abilities of neural networks with the humanlike knowledge representation and explanation abilities of fuzzy systems. As a result, neural networks become more transparent, while fuzzy systems become capable of learning [9]. A Neuro-fuzzy system is a neural network that is functionally equivalent to a fuzzy inference model. It can be trained to develop IF-THEN fuzzy rules and determine membership functions for input and output variables of the system. Expert knowledge can be easily incorporated into the structure of the Neuro-fuzzy system. At the same time, the connectionist structure avoids fuzzy inference, which entails a substantial computational burden [10].

4. Method

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 inputs and one output of which rules were generated. A domain Medical expertise definitions are injected in to the knowledge based where the system would use to make decisions and draw a conclusion. MATLAB was used to implement this experiment using fuzzy logic and Neural Network toolbox.

5. Analysis of Data Collected

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.

6. ANFIS Model

The figure below shows mapping between the inputs variables to the input membership functions to the rules generated by the system to the output membership function then to the final output.

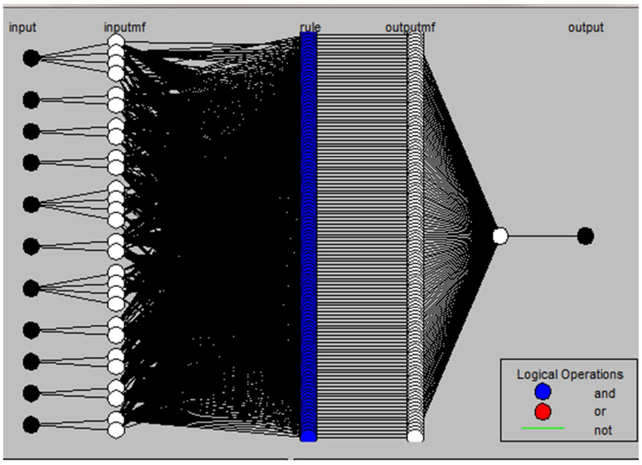

Figure 1. *Mycobacterium tuberculosis system.*

7. Surface Viewer

When the parameter cough for two weeks and cough with blood were plotted against the Result, it is observed that if cough exceed one week. The patient has the high possibility of TB and vice versa. Highest possibility occur when both the cough for two weeks and cough with blood are presence as shown in the figure 2 below.

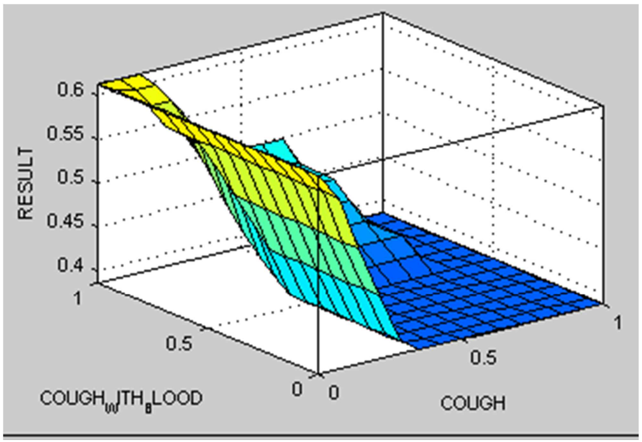

Figure 2. *Cough with blood and cough for two weeks against result.*

The input parameters Night sweat and cough for two weeks were plotted against the Result, it is observed that if cough exceed one week. The patient has the high possibility of TB and vice versa. Highest possibility occur when both the Night sweat and cough for two weeks are presence as shown in the figure 3 below.

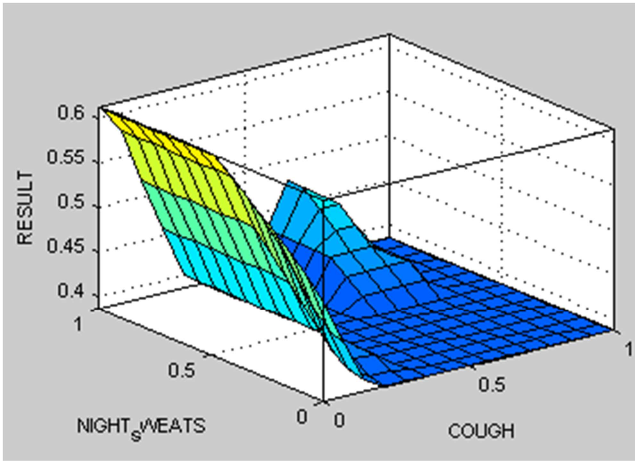

Figure 3. *Night Sweats and Cough against Result.*

Input parameters difficulty in breathing and cough with blood both at the high range plotted against TB or Not TB it is observed that there is possibility of TB but not at a high level as shown in the figure 4 below.

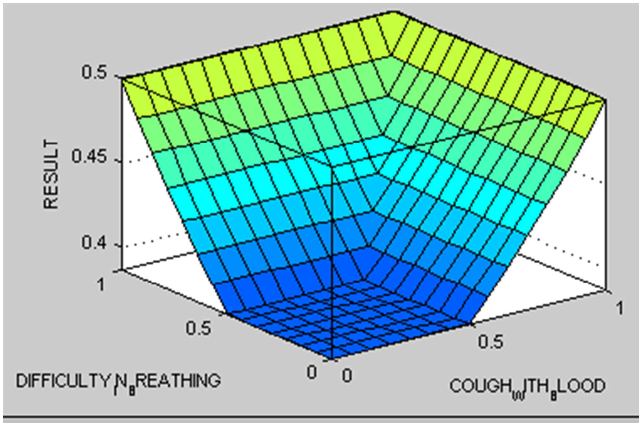

Figure 4. *Difficulty in breathing and cough with blood plotted against result.*

8. Conclusion

The diagnosing tuberculosis system is based on Neuro-Fuzzy approach. It is designed for diagnosis of tuberculosis disease in human. This system consists of eleven (11) input variables as indicated. which are; 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 which consists of 120 rules is used to determine one output parameter: Pulmonary Tuberculosis and No TB according to the eleven (11) inputs parameters. Gaussian fuzzifier are employed as membership functions the rule base is designed based on knowledge of domain experts interviewed, while Sugeno inference engine is adopted for this research work. We used center of gravity method for the defuzzification in this research. Linguistics variables such as mild, moderate, severe, very severe, Yes and No were used. These variables are used to map to the next stage up to the final output that the system produces.

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