Generating an Artificial Intelligent System to Diagnosing Thyroid Gland Related Diseases using Fuzzy Logic and Neural Network

[1]Ugur Kesen, [1]Emre Canayaz and [1]Ali Sarıkas
[1]Electronics and Automation Program, Vocational School of Technical Sciences,Marmara University, Turkey

Abstract

Nowadays, the number of diseases related to the thyroid gland function inefficiency is increasing all around the world. Studies show the ratio of incidence of this kind of diseases is between 10% - 20%, in Turkey. Early diagnosis is crucial to prevent irremediable events related with thyroid disorders and reduction of financial burden for medication of these diseases. Thus, blood tests, especially T3, T4 and TSH are essential for diagnosing thyroid gland related diseases. In our study, we generate a Mamdani type Fuzzy Logic system and an Artificial Neural Network system to create an insight about thyroid related diseases. Our systems give advice to users with regarding to their T3, T4 and TSH results and warn them if there is inconsistency. Real data set of healthy and diagnosed patients' blood test results were used. Our results show that although presented Artificial Neural Network system as easy to implement as Fuzzy Logic System but presented fuzzy logic system creates more accurate results.

Key words: Fuzzy Logic, Artificial Neural Network, thyroid gland function inefficiency

1. Introduction

All over the World, thyroid disorders are one of the most common diseases, especially in Turkey. In Turkey, scientific studies pointed out that the risk for getting a disease related with thyroid gland function inefficiency is very high [1]. According to Aktolun [2], 10% to 20% of the Turkish population suffers a disease connected to a thyroid gland. Diseases caused by thyroid gland are classify as serious illness and need to be followed very strictly.. In thyroid gland diseases blood tests play a crucial role to diagnose related diseases and to show efficacy of the treatment [3, 4]. Particularly, to keep the thyroid-stimulating hormone (TSH) in blood in certain intervals is important, but following only TSH alone is not enough [1]. Triodothyronine (FT3), free Thyroxine (FT4) levels and presence of thyroid microsomal (anti-TPO) antibodies should be tested to make proper and accurate diagnosis [5]. Test results must be interpreted by a physician or endocrinologist.

Examination time for every patient is limited; therefore healthcare professionals' prognosis can be inaccurate. According to the statement by the Guatr and Troid Cancer Society [6] the surveys made to raise awareness about the thyroid illnesses which contain biologic and biochemical equilibriums are insufficient and in some cases misguiding. Sometimes the illness only includes

*Ugur KESEN: Address: [1]Electronics and Automation Program, Vocational School of Technical Sciences, Marmara University 34722, İstanbul TURKEY. E-mail address: u.kesen@marmara.edu.tr, Phone: +902164182 06 Fax: +902164182505

some of the symptoms given in the items. Therefore wasting valuable time needed for early treatment. The main purpose of the method developed by the study is to develop two artificial intelligent based software to guide medical staff and patients with insufficient clinical training to understand thyroid blood test results. One of them based Fuzzy Logic Theory and the other one based on Artificial Neural Network Theory.

Fuzzy Logic theory has a great potential to deal with the uncertainty by simple reasoning. Fuzzy set theory provides mathematical tools for carrying out approximate reasoning processes when available information is uncertain, incomplete, imprecise, or vague [7]. Fuzzy Logic and Fuzzy Set theory have been used in diagnosis of diabetes, pancreatic diseases, breast cancer, hepatitis and cortical malformations. Thus developing a flexible rendering system to guide the patient as thoroughly as possible is the main objective. Unlike the previous studies about forming an "intelligent system" to help to guide patients about thyroid disorders [8,9], this prototype compare four different blood tests and make a reasonable bound between inputs and output by using simple linguistic rules. There is an important point to keep in mind that to form the mathematical representation of fuzzy sets and fuzzy intervals, an endocrinologist's experience was used.

Artificial neural networks (ANN) are computational models inspired by central nervous systems of animals to generate systems that capable of performing tasks like machine learning and pattern recognition. In ANN, interconnected neurons enable to compute values as output from inputs feeding information through using neuronal network [10, 11]. In this study other than Fuzzy Logic based system we present an ANN based multilayered network system. These multilayer systems can implement arbitrary complex input/output mappings or decision surfaces separating pattern classes. The multilayer perceptron (MLP) systems generally formed using an input layer, one or more hidden layers and an output layer. The processing units are calculated in layers. We used error back propagation algorithm to do calculations to network increase approximates the desired response [12].

Proposed systems' main goal is comparing the test results to to give the right advice to the user about his/her thyroid. All systems efficiency tested comparing results of proposed systems using same data sets of blood test results of the healthy and unhealthy subjects. Results indicate that Fuzzy Logic algorithm is more adaptable than proposed ANN system and it generates outputs as precise as proposed ANN system.

2. Materials and Method

In this part of the paper, proposed Fuzzy Logic System and Artificial Neural Network System described separately.

2.1. Proposed Fuzzy System

For this system we used, Mamdani type fuzzy logic sets are created by using MATLAB

programming language (Figure 1). Moreover, a set is identified for each input value and membership values are assigned depending on the magnitude of the inputs. Also, results by the input values are formed according to the rules defined in the fuzzy logic, and for the possibility of a patient with a thyroid disorder.

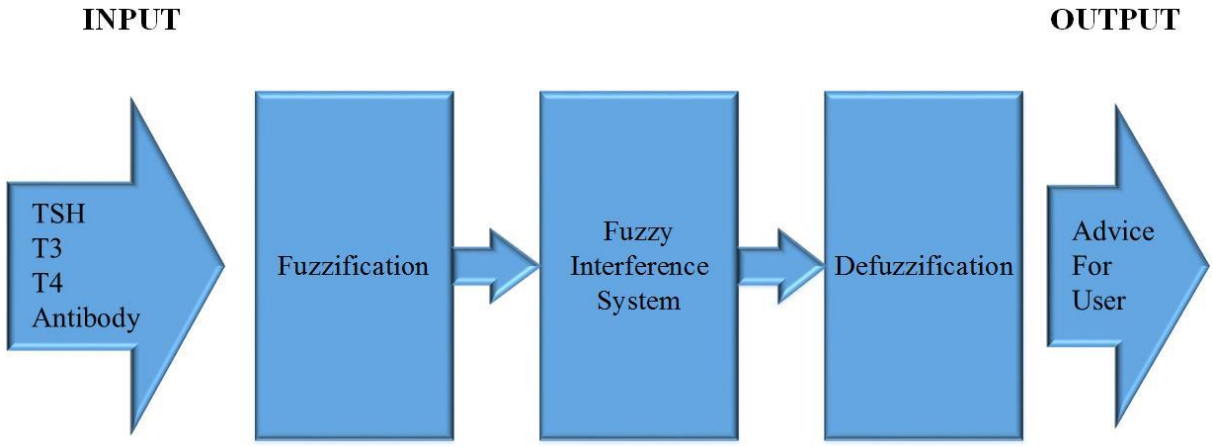

Figure 1. General Structure of Fuzzy Logic System

We have formed three mostly used blood tests' mathematical model for functional disorders of the thyroid gland as our fuzzy logic system inputs through the [1, 4]. These tests can be listed as TSH, T3, T4 and anti-TPO (Figure 1). During the opening of the program, our system evaluates that the antibodies' tests are positive or negative mentioned in the introduction section. Sample membership function for T3 Blood test can be found in Figure 2.

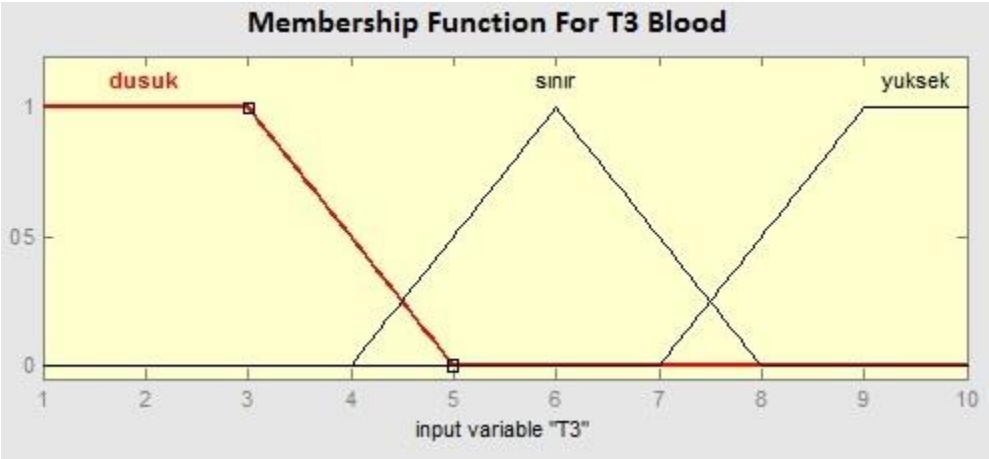

Figure 2. Fuzzy logic membership functions and range of input values for T3 test

This part of the system establishes a logical relationship between output and input (Figure 2). Totally there are nine linguistic rules that perform this connection between output and input. Some of the rules are given in Table 1.

Table 1. Three of nine rules used in the system

Rule 1	If both TSH and T3 are **Low** and T4 is **High**, output is **Emergency**.
Rule 3	If both TSH and T3 are **High** and T4 is **Normal**, output is **Boundry 2.**
Rule 4	If TSH, T3 and T4 are **Normal**, output is **Healthy**.

Also, system has to defuzzify the calculated data. Output is clarified with 'Centroid' method according to the inputs' values. Output is a statement about what the user should do according to his/her test results. There is four different scenarios about diagnosis. For example; if user's probability to become thyroid patient is high, his/her output will be "There is a high probability that you are suffering from thyroid disorder. You should see an endocrinologist".

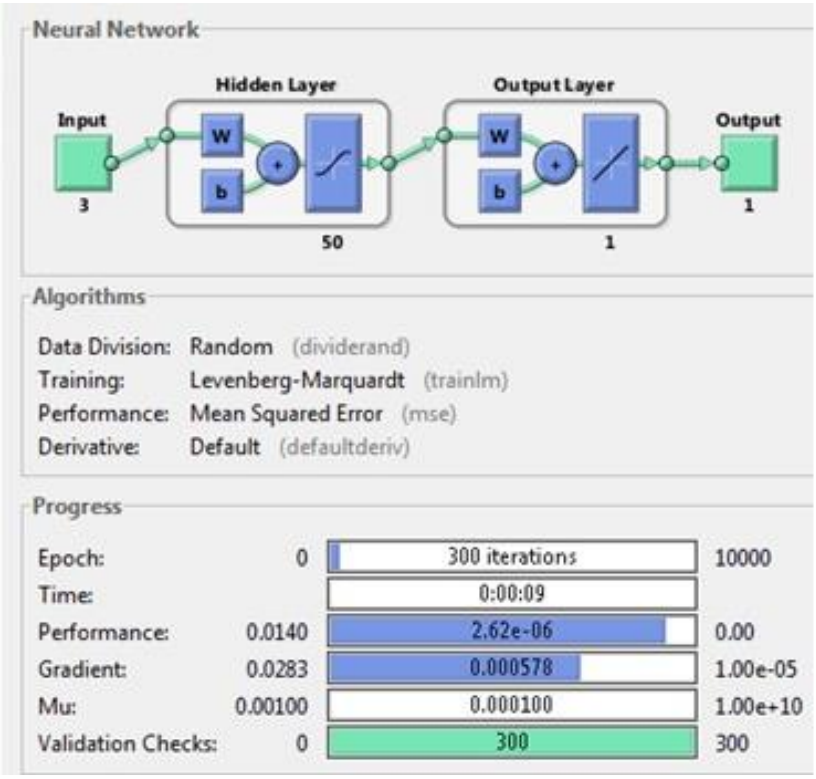

Figure 3. Multilayered ANN system's general structure

2.2. Proposed ANN System

For this system we used ANN Multilayer networks. We formed ANN model according to our input and output information. For input we used T3,T4 and TSH blood test results coming from the data set. Output layer consists of 4 different scenarios about diagnosis (Figure 3). Structure consists of 3 inputs, one output, and two layers. In hidden layer there are 50 neurons. Moreover

the transfer function was settled as tanjant sigmoid (tansig) function. At the output layer linear activation function was used.

3. Results

System's stability was tested with 300 different test subjects. 200 of these subjects have thyroid dysfunction or related diseases and 100 of the test subjects are healthy. All of the test subjects' T3, T4,TSH and anti-TPO results are loaded to two system and proposed systems decided the test patients are healthy or not. Therefore system acts like an expert. If the systems decided the test subject had some kind of thyroidal disorder, warned them to take the test again or see an endocrinologist. In Figure 4 comparisons of the two systems results as classification of data sets as healthy or not (Figure 4, Figure 5).

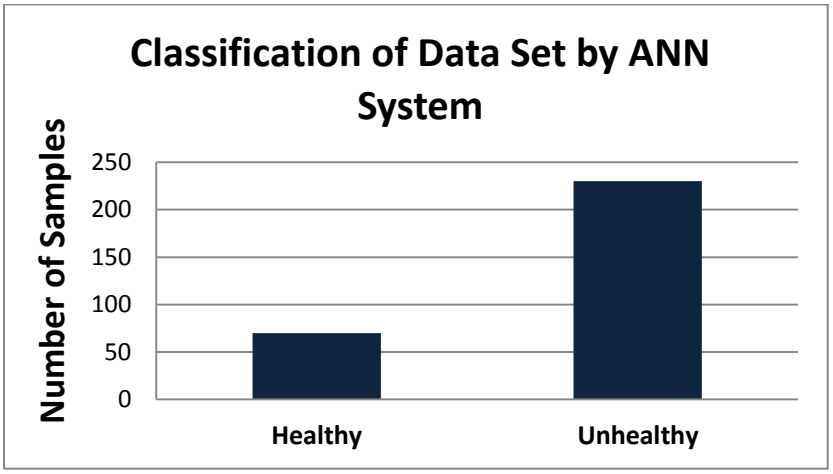

Figure 4 Classification of Data Set by Fuzzy System

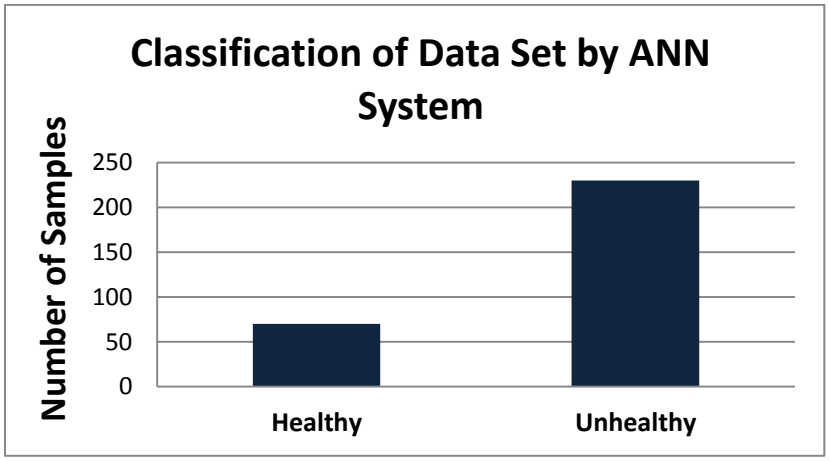

Figure 5 Classification of Data Set by ANN System

As presented in the figure above (Figure 4), according to the Fuzzy System 60 data classified as healthy and 240 data classified as unhealthy. In data sets there was only 200 data unhealthy. Therefore, we can calculate that 100% of all unhealthy data recognized. In contrast to this fact only 60% of the healthy data was correctly grouped. In figure 5 100% of the unhealthy patients advised correctly but only the 70% of the healthy data sets classified correctly.

4. Conclusions and Future Work

Aim of this study; facilitate to be noticed by people who have not medical experience for disease caused by thyroid gland insufficiency. For this purpose two different artificial intelligent based systems were developed. According to the results, systems are promising, especially to classify unhealthy patients according to their blood test results. As discussed in detail above, program compiles the results of basic four blood tests applied on patients.

Our results are parallel with previous studies about forming expert systems for thyroid insufficiency [13]. To give more accurate recommendations, number of inputs was increased [13]. Moreover, parallel to this normal value ranges highly depend on age. So, in the next step of this study, the value ranges of fuzzy logic functions used to blur the age variable must also be modified and proper calculations can be added to ANN system. Should be noted that, knowledge of physicians have been utilized in this project. So, evaluating of ideas and reviews of more experienced physicians will be beneficial as we imply in our previous studies about this topic.

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