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Anemia Diagnosis By Using Artificial Neural Networks

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Abstract – In the last years, applications of artificial intelligence for diagnosis of diseases as a decision support system has been widely used. In these applications, the state that if the patient contracts to the suspected is classified as positive or negative. Although in the previous works which use artificial neural networks various diseases especially some cancer types have been studied, anemia has remained as an disease that has not been focused. Anemia which can emerge due to the degeneration of blood structure, blood loss or elimination of erythrocytes is a disease that is widely encountered and can result in significant health problems. In this study, a decision support system using artificial neural network has been proposed for the diagnosis of anemia according to the selected comprehensive blood laboratory test.

Keywords – Anemia, Artificial neural networks, Artificial intelligence, Blood values, Diagnosis; Erythrocyte.

I. Introduction

Today, diagnosis of diseases is one of the most important fields in medical practice which can help to apply treatment at its early phases of the disease. . Realization of diagnoses with high accuracy and early treatment can prevent the progression of a chronic disease which can be more harmful, even, life-threatening in further levels [1]. Highly accurate diagnoses play an important role in the development of health services by contributing to treatment and subsequent healing processes [2]. Uncertainty in the information required for diagnosis and applying correct treatment is one of the fundamental and critical problems. Different types of uncertainties can affect the decision-making process in the medical field. Medical diagnostic research is an important part of this decision-making process which perform complex tasks that require consideration of the interaction of many parameters. Doctors are confronted with the personal experience of each patient and medical information from various sources. Often, they focus on symptoms and indicators of disease which can be ambiguous and complex. Then they make an inference based on these findings with the patient's health history, physical examinations and laboratory results. This process results in the diagnosis of diseases [3].

Diagnosing a patient's condition depends on many factors such as knowledge, experience, education, available resources and communication skills [4]. In this context, classical medical diagnostic systems have the most inclusive nature for the situations need to be diagnosed in accordance with their aim of development. However, these systems do not have the ability to predict and foresee that a disease may result from a combination of affects related to other diseases or interaction of several parameters [5]. Therefore, it is very important to design a system that can diagnose complex diseases with high accuracy and precision. Artificial intelligence (AI) applications can be used to diagnose diseases by creating a decision mechanism. The aim of this study is to determine anemia disease by using artificial neural networks and to reveal the possible treatment methods of this disease with artificial intelligence.

Anemia is a disease caused by deterioration of blood structure, blood loss or elimination of red blood cells (RBCs). It is a very common blood disorder that can lead to very serious health problems. Many symptoms associated with anemia, such as fatigue and tiredness, are often thought of as silent discomfort and ignored, as healthy individuals usually face same situations in their daily lives. As a result, diagnosis of anemia can often be overlooked and the disease cannot be treated. Untreated anemia can lead to severe fatigue, heart problems, and even serious health problems that can be life-threatening [6,7].

Because of these reasons, determining diagnosis of the anemia disease in a timely and correct manner is very important. Diagnosis of diseases, especially anemia, depends on different parameters, abnormalities that may occur in blood values, and interpretation of physicians. Nowadays, the procedure applied to understand the anemia disease is quite standardized from the beginning to the last stage. In this process, after blood is drawn from the patient, the blood in the tubes is passed through the biochemistry laboratories for the necessary tests. These processes are usually performed on complete blood counting (CBC) device which is the most common blood test equipment in the laboratory. These devices usually automatically calculate whether the blood values they are analyzing are above or below the reference range and mark the values that are low or high. Later, the diagnosis of the disease and the application of the necessary treatments are determined by the experience, knowledge and interpretation of the doctors. Especially accurate and highly accurate diagnosis of the disease is critical for the detection of possible treatments.

In our study, the reasons of anemia disease were and blood parameters that can have abnormality in anemia are investigated. Today, one of the most important points in medical treatment are the method and laboratory equipment used for diagnosis. If the diagnosis of diseases is based on a single blood value or more than one blood value, the process can be evolved to a more robust state using artificial neural networks. Moreover once the diagnosis has been made, a decision mechanism can be established to remove possible treatment modalities for the disease. After the treatment, it is checked whether the blood values showing abnormalities come back to the reference range, and accordingly, the actual state of treatment can be specified using artificial intelligence. If the treatment is not achieved its goal, another method may be used by creating possible treatments again.

Anemia occurs when the number of red blood cells produced is less than the number of red blood cells destroyed. This can be attributed to a reduction in effective RBC production or to the formation of ineffective erythrocytes. Common causes of reduced RBC production are lack of nutrients such as iron, B12 and folic acid. In this study, it is aimed to build a system that inherently encapsulates the correlation between parameters and diagnose by examining blood values of healthy individuals, especially B12 and folic acid values. In order to make a medical decision system for automatic diagnoses, an artificial neural network based model is introduces in this study.

II. Artificial Neural Networks(ANN)

Artificial neural networks are, in the broadest sense, information processing systems that mimic the working principles of the human brain or central nervous system. In the shortest description, artificial neural networks collect information about samples, make generalizations, and then using information learned in comparison they make decisions on those samples have never seen before. The work on this subject began with the modeling of neurons, the biological units that make up the brain, and their mimicking their computational functions in computer systems [8]. In the biological world, neurons are connected to the so-called synapses, and the same structure is applied to computer systems. Every link here has a numerical weight that expresses the importance of entry. The weights are the fundamental elements of the long-term memory in ANN. A neural network performs learning by repeatedly adjusting these weights. Here learning is directly related to network topology. The optimal architecture for the network should be large enough to learn the problem and small enough to make generalizations. A smaller network than the optimal one cannot learn the problem well, and if it is a bigger network, it memorizes the training data or in other words it cannot generalize. Artificial neural networks have gained importance along with the progress in robotics and autonomous systems. Especially it started to be widely used in in health, automotive and defense industry studies [9]. It is frequently used especially in optimization, classification, control, decision making and forecasting based studies.

As seen in Figure-1, artificial neural networks consist of 3 main layers. These; the input layer, the hidden layer, and the output layer. Artificial neural networks have five basic elements. These are inputs, weights, coupling function, activation function and outputs.

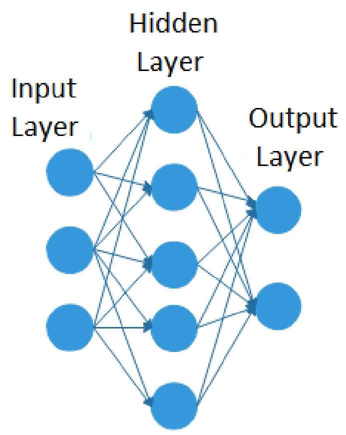

Fig. 1 Artificial Neural Networks Structure of the System

A data set containing N samples in the classification problem can be expressed as D={(x(k),t(k)|x(k) ∈Rn, t(k)∈Rp, , k={1,…,m} Here x(k)=[x1(k) x2(k) … xn(k)]T represents the feature vector of the kth sample and t(k)=[t1(k) t2(k) … tn(k)]T represent the target outputs. The input of every neuron in the hidden layer is the weighted sum of the neurons in the entrance layer. M neurons in the input layer, the input of jth the neuron is given by the equation (1).

$$z_j^{(1)} = \sum_{i=1}^{M} w_{ij}^{(1)}.x_i + b_j^1 \quad (1)$$

Here w_{ij} is the weight multiplier between the ith input layer and jth hidden layer neuron. b_j is the threshold value for this neuron. The outputs of the neurons in the hidden layer are obtained using a non-linear activation function. The output of the ith neuron is expressed by the equation (2):

$$a_i^{(1)} = g(z_i^{(1)}) \quad (2)$$

The input of the ith neuron in the output layer is similarly obtained by linear weighting of outputs of previous hidden layer.

$$z_j^{(2)} = \sum_{i=1}^{N} w_{ij}^{(2)}.a_i^{(1)} + b_j^{(2)} \quad (3)$$

Table 1. Blood Value Table

Test Name	Reference Value	Unit
Glucose (in hunger)	70-105	mg/dL
Creatinin	0.7-1.3	mg/dL
LDL-Cholesterol	<130	mg/dL
Trigliserid	50-150	mg/dL
ALT	0-55	U/L
GGT	8-64	U/L
Hemoglobin	13.5-18	g/dL
Hematocrit	36-50	%
Erythrocyte	4.5-5.8	M/µL
Leukocyte	4.5-11	bin/µL
Trombosit	150-400	bin/µL
MCH	150-400	pg
MCV	80-96	fL
MCHC	30-36	%
RDW	8-18	%
MPV	7-12	fL
Neutrophils	2-7.8	bin/ µL
Lymphocytes	1-4	bin/ µL
Monocytes	0-1	bin/ µL
Eosinophils	0-1	bin/ µL
Basophils	0-0.2	bin/ µL
TSH	0.35-4.94	µIU/mL
Vitamin B12	138-652	Pg/mL
Folic acid	3.1-20.5	Ng/mL
Uric acid	3-7.2	Mg/dL
Glomerular Filtration Rate	>60	ml/min/1.73m²

As a result, neuron output in the output layer is obtained by a non-linear activation function as in(4)

$$a_i^{(2)} = g(z_i^{(2)}) \qquad (4)$$

For the classification problem, nonlinear sigmoid function given by (5) is considered to be used.

$$g(x) = \frac{1}{1+e^{-x}} \qquad (5)$$

According to the (5) the system output will be between 1 and 0. If the system has a single output, the threshold value of 0.5 is used to compare the output and the result is obtained as 1 or 0 which represent positive and negative decision on the existence of the disease, respectively. If the system has multiple outputs for diagnoses of several diseases, the output with the greatest value is 1 and the others are 0. ANN performance is evaluated by the cost function defined according to the error compared to the target output and the output of the system. The cost function J (w) is given by (6).

$$J(\omega) = \frac{-\sum_{i=1}^{N} y^{(i)} \log a^{(2i)} + (1-y^{(i)}) \log(1-a^{(2i)})}{N} \qquad (6)$$

Here a$^{(2m)}$ is the m*th* the value of the output layer for the example. Weights are updated with back propagation according to the gradient of the cost function in the learning phase.

$$w_{ij} = w_{ij} - \alpha \frac{\partial}{\partial w_{ij}} J(\omega) \qquad (7)$$

In the proposed model, 26 blood values that are included in the comprehensive blood test given in Table I are accepted as input data for the detection of anemia. Similar studies have been previously conducted for the diagnoses of breast cancer and prostate cancer [10,11]. In the proposed model, the input layer has a structure with 26 inputs and the output layer has a structure with a single output. If ANN identifies the diagnosis of anemia in the output layer as positive, it will yield 1 and if it identifies it as negative the output will be 0. The input is an Nx26 matrix, and the output is Nx1 matrix whose elements represent the estimated diagnose. Before the system training, the training data must be passed through the mean subtraction and scaling pre-process. For this pre-processing mean values of M blood values are found over N samples. Then the mean value is subtracted from the blood value of each example and finally each blood value is divided by its range which is the difference of the maximum and the minimum values of the reference values specified in Table I. In this way, the effects of input values at different intervals on the system are balanced and the parameters whose original value is too big compared to the other blood parameters are prevented from being dominant in the system. The number of neurons in the hidden layer will be determined according to the classification result on the test data. The number of hidden layer neurons in the final structure will be adopted as the number that no longer provides improvement in the classification result even if it is further increased.

III. RESULTS & DISCUSSION

In this study, a decision support mechanism using artificial neural networks is proposed to be used in the diagnosis of anemia. Comprehensive blood test results including 26 blood values for the proposed structure are accepted as system input. The presence of anemia disease as a system output is classified as positive (1) or negative (0). The results of this study will be compared with similar constructs such as Anfis (Adaptive Neuro-Fuzzy Inference System) and presented as an helper diagnostic tool in the future

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