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Predicting Patients with Renal Failure using Neural Networks

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Abstract

Artificial neural network considered as most important in statistic and artificial intelligent that reflex important improvement for future prediction a series of time data from 1999 to 2018, which represent 20 series of time data represent renal failure patients men and women, bath. Results of the research reach predictions in three years represented in the following years (2019-2020-2021). Through results the predictions values have best used way from traditional used way in prediction previously. The documents loosed on researchers from Ibn Seena Hospital in Nenavah Governorate in renal failure.

Keywords: Prediction, Patients, Renal Failure, Neural Networks.

The Introduction

The process of predicting future values is one of the basic objectives in statistical of sciences, as prediction is of great importance in the process of planning and decision-making in all fields, and through prediction it is possible to identify the circumstances and the situation surrounding the problem under study before making any decision. Therefore, the subject of forecasting has received great and increasing interest from researchers and decision makers.

Researchers have been interested in developing different methods for the purpose of making predictions, and prediction using neural networks is one of means for prediction in the global system (Ajanwachuku& Austine, 2019).

The prediction is mainly based on the model parameter estimates fitting the time series data (Jie, Shunping, Jian and Youcun, 2023).

The importance of the research lies in the fact that it is based accurately on the results achieved, with patients with kidney failure, for women and men (and all together), as the results of this research will shed light on the expected achievements or predict them in three consecutive years (2019-2020-2021).

The Theoretical Side

The A time series is a sequence of observed values of a particular phenomenon ordered over time, and these values are usually not independent; that is, they depend on each other, and the lack of independence is exploited to reach reliable predictions.

It is also used to predict the change of this phenomenon in the future due to the ease of conducting the study on the one hand, and the ease of obtaining appropriate quantitative and qualitative

information and good results that cannot be reached when using appropriate information methods in contrast.

It can be said that the main goal in the time series methods is to obtain models that can be used to describe the problem and, as a result, to predict the future of the studied phenomenon.

The time series is defined as if it represents the observation t in the time series (xt), the sequence of is the order of random variables $(X_t) or (X_t; t = 0,1,2,.....)$ (Stephen, Marcus, William, 2023).

Knowledge of Multi-Dimensional Probability Space:

First: The Time Series:

1. **Factors Affecting the Evolution of Time Series:**

   The evolution of the recorded phenomena in the time series may be the result of many factors, including: economic factors or seasonal factors, and some of these factors may affect the general trend of the time series in the long term. Others are in the formation of short-term oscillations (Pranati Sahu, 2025).

   A. The General Trend (Tt) Trend:

   The general trend, regardless of whether it is an upward or downward trend of the studied phenomenon, reflects the development of the phenomenon over a long period of time (Stephen, Marcus, William, 2023).

   B. Seasonal Changes (St):

   Seasonal changes are meant by frequent changes according to a specific pattern or repeating themselves usually, but to a varying degree, which may differ from time to time. Climatic factors and social traditions are among the most important factors that affect seasonal changes, and it is important to anticipate these changes when making decisions (Amin Bey, 2005).

   C. Cycle Variations C+:

   Periodic changes may cause fluctuations in the activity of the time series, and the cycle consists of a period of expansion followed by a period of contraction, and these cyclical changes are usually recurrent, but they do not occur at regular intervals and may take a year to 5 years or more.

   D. Random Changes (Rt):

   Are those oscillations that are the result of random factors out of control these variables can not predict them.

2. Mathematical Models For Time Series

A. Autoregressive Model (AR):

The stochastic process, $\{x_t . t = 0.1.2 \ldots\}$ is said to be a p-order autoregressive process. Which is denoted by $AR_{(p)}$and which achieves the following equation:

$$X_t = a_1 X_{t-1} + a_2 X_{t-2} + \cdots + a_p X_{t-p} + e_t \ldots\ldots\ldots 1$$

Where $a_1 , a_2 . \ldots\ldots\ldots\ldots , a_p$ are the autoregressive parameters.

e_t: represents the random error term at time t, which is a random process (Makridakis, 1998).

B. Moving Average Model (MA):

The stochastic operation is called, $\{x_t . t = 0.1.2 \ldots\}$ is a moving media process of order q which is denoted by (MA) if it satisfies the following equation:

$$X_t = e_t + b_1 e_{t-1} + b_2 e_{t-2} + \cdots + b_p e_{t-p} \ldots\ldots\ldots 2$$

Where: $b_1 , b_2 \ldots . , b_q$ the Moving Average Parameters.

e_i: random error.

C. (Auto Regression Receive Moving Average Models) (ARMA):

The basic elements of the autoregressive model and moving media can be combined to obtain a variety of models called autoregressive with moving media of the order($p.q$), that is, ARMA (p, q), and it is as follows:

$$X_t = e_t + a_1 X_{t-1} + a_2 X_{t-2} + \cdots + a_p X_{t-p} + e_t + b_1 e_{t-1} + b_2 e_{t-2} + \cdots + b_p e_{t-p} \ldots\ldots\ldots 3$$

Second: Artificial Neural Networks (ANN):

They are computational methods developed to simulate the way the human brain processes information a specific task, through huge processing distributed in parallel, and aconsists of simple processing units, these units are nothing but computational units called neurons or nodes that have a neurological property, in that they store Practical knowledge and empirical information, making it available to the user by the weights. Neural network models have proven their ability to predict and solve problems accurately. Where the networking method can be applied without regard to prediction

Neural networks consist of three layers, the input layer, the hidden layer, and the output layer.

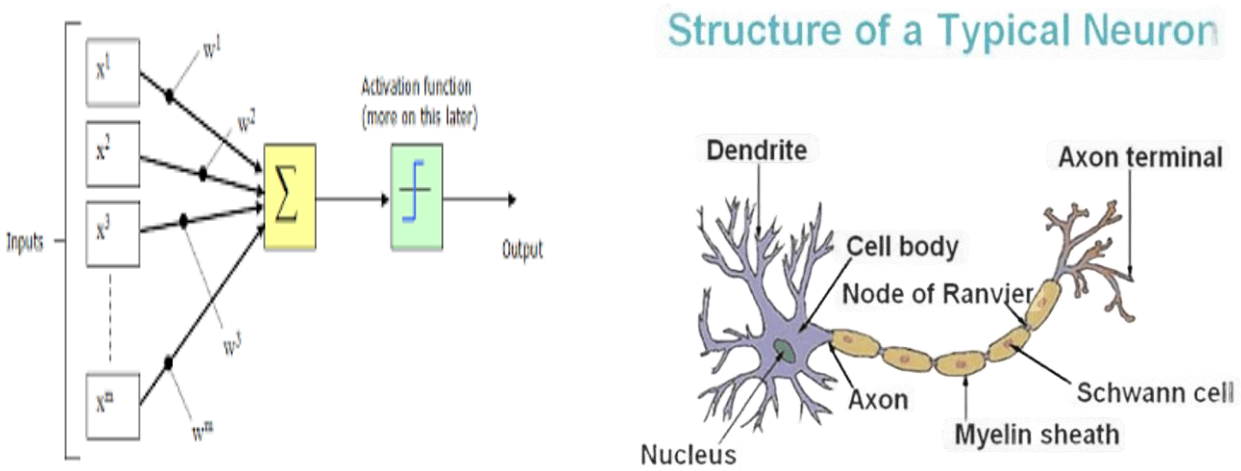


Figure (1): represents a comparison between an artificial nerve cell and a natural cell

Researchers in the field of neural networks use various types and techniques in designing neural networks, including:

1. Feed-Forward Network:

This network is considered one of the most widely used networks, and these networks do not contain a closed loop of interconnections between its constituent units. The network consists of at least two layers.

The feed-forward network allows signals to pass in only one direction from input to output, and there is no reverse feed, meaning that the output from a certain layer does not affect the same layer. This type of network is used to identify patterns, as shown in Figure 2.

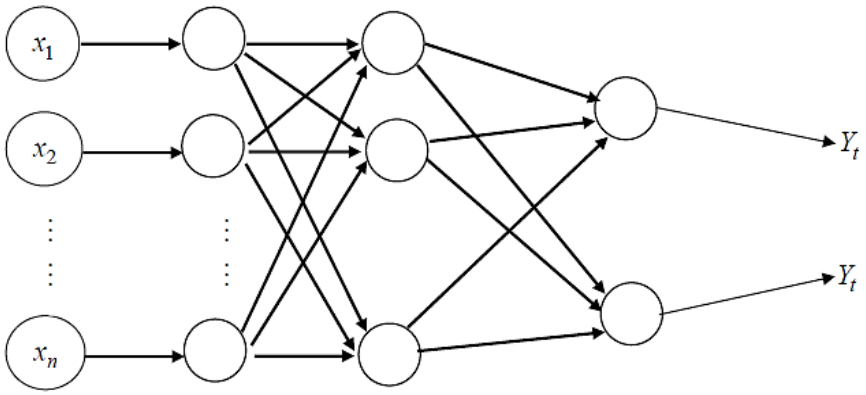


Figure No. (2) Represents the front-feeding network

2. Feed-Back Network:

Feedback networks can contain signals that pass in both directions by inserting loops of repetition in the network. This type of network is very strong and complex to a large extent. The feedback network is variable and dynamic, as its states constantly change until it reaches the point of balance.

It remains at the equilibrium point until the input changes and needs a new equilibrium point. A network of this type is referred to as an interactive network.

As for networks with a single layer and reverse feed, it is called the recurrent network. It is a two-layer network with feed forward, as in Figure 3.

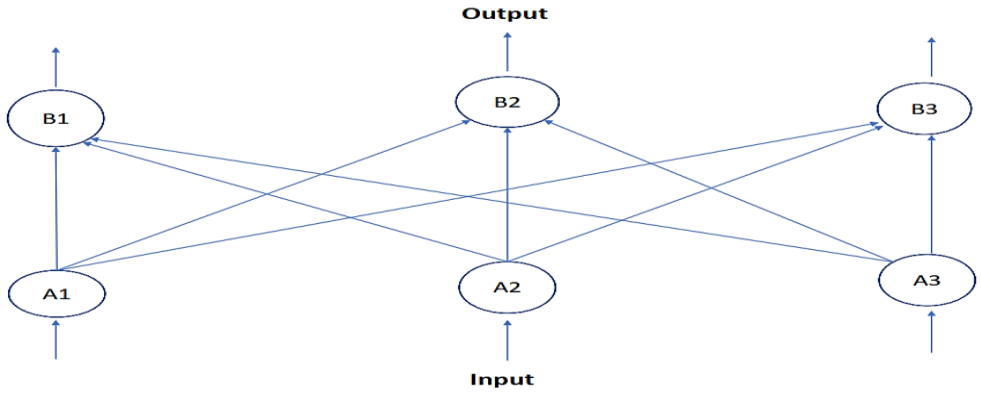


Figure No. (3) Represents the feedback network

And networks consisting of two layers with feeding in the forward and reverse directions (Feed Forward Feed Back Ward) as in Figure (4).

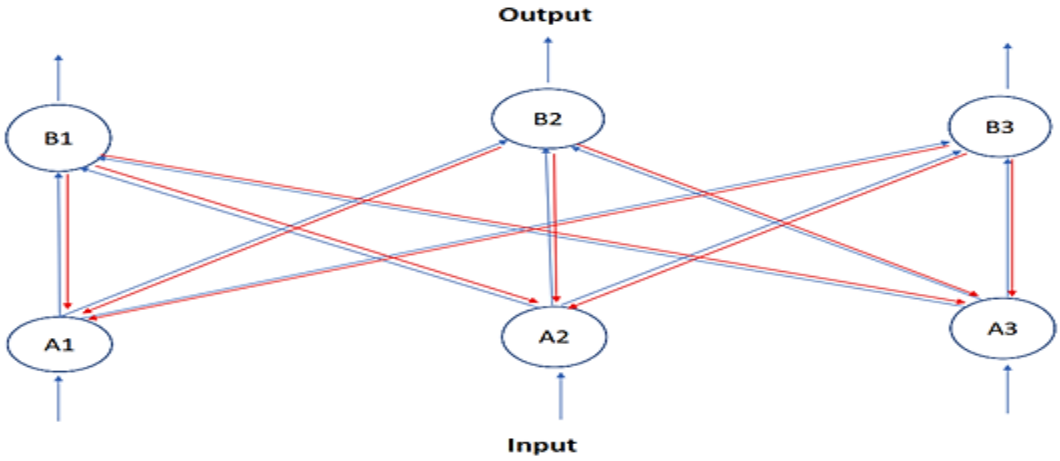


Figure No. (4): Represents the network with feeding in the forward and reverse directions

The key model of artificial neural networks is represents the structure of an information processing system that links and organizes a large number of internally linked processing elements (neurons) that work in harmony with all the specified means. The signals pass between nodes (neurons) through connecting lines. The input to the nodes (neuron) with these weights and the weighted inputs are collected in the nodes or neurons, and then the outputs of each node are processed by a non-linear function with a certain threshold known as the activation function.

Neural networks have given high efficiency quality to the many applications in many fields, including:

1. Recognizing patterns and recognizing images.
2. The ability to recognize distorted images.
3. Completing the images that were partially lost before the images sent by satellite.
4. Classification processes into a number of categories. (Amin Bey, 2005)

3. Back-to-Back Error Neural Network (BPNN):

The network (BPNN) is one of the most widely used artificial neural networks, which may seem complex, but it´s much easier than the level of understanding and programming, and it has the ability to deal with nonlinear issues and has many applications in image processing, signal processing, and speech recognition. It was developed in the mid-1970s by (Rumelhart Hinton and Williaras)

As the goal of the network is to reduce the error by adjusting the weights by comparing the actual output of the network with the desired output (Target Output). (Sumathi, 2010)

4. The Use of Neural Networks in Prediction:

Assuming that there is a time series that contains the observations $[X_1.X_2.\dots\dots.X_{n-1}.X_n]$ and to speculate on the future values of the variable, in the sense of finding the values $X_{n+1}.X_{n+2}$.

As if the series is defined in the sense of the existence of a real number p which is called the Embedding Dimension and the function f such that $t > p$.

$$X_{(t)} = f\left(X_{t-1}.X_{t-2\,\dots\dots}.X_{t-p}\right) \dots\dots 4$$

Thus, the prediction consists in N, the value of the time series is given, and to find the values of $(p.f)$, and assuming that p is known, and we want to find a function f, and it is known that artificial neural networks are composed of a large number of simple non-linear interconnected elements, there are three types of units:

A. Input unit: which prepares the values in the time series $X_{t-1}.X_{t-2\,\dots\dots}.X_{t-p}$

Where p is the embedded dimension.

B. Hidden units: which are used to save the internal representation of the time series.

C. Output units: which give the output of the neural network in the case of an output unit only to return.

Network Architecture:

BPNN consists of two main phases:

A. The First Stage is the Forward Pass:

At this stage, the values of the output signal are calculated for each cell in the network layers, starting from the input layer towards the output layer, that is, the output signal for any cell does not affect except in the next layer, and this stage ends with calculating the error signal between the actual output (Actual Out Put) of the network and the desired output (Target Output).

B. The Second Stage: The Back Ward Pass:

At this stage, the weights are modified in a direction that allows the error signal to be within the permissible level, so the output signal of the network is re-deployed to correct the input signal in the direction of any of the output layer to the input layer where the modification is made. Weights (Qasim, Mohammed, 2013).

5. BDNN Algorithms:

The First Step:

Initialization of the initial weights $(W_X = W_1, W_2, \ldots\ldots\ldots W_n)$

θ : The Threshold value.

The Second Step:

Choose a training pair $((X_N), Y_i))$, as (X_N) is input $((X_N = x_1, x_2, \ldots\ldots\ldots, x_n)$ represents the required output (Target) $(Y_j = y_1, y_2, \ldots\ldots\ldots, y_j)$.

The Third Step:

In the front direction, the real output value is calculated as follows:

1. Calculate the real output value from the output layer to the hidden layer:

$$net_H = \sum_{i-1}^{N} [X_{ij} W_I - \theta_I] \ldots\ldots\ldots\ldots 5$$

N: The number of elements in the input layer of the network. Also, $Y_H = f(Net_H)$

2. Calculating the real output value in the hidden layer to the output layer :

$$net_{H0} = \sum_{i-1}^{N} [Y_{Hj} W_J \theta_J] \dots\dots\dots\dots 6$$

p : is the number of elements in the hidden layer $Y_0 = f(Net_{H0}) \dots\dots\dots 7$

The Fourth Step:

Calculate the error as follows:

1. Calculate the error between the hidden layer and the output layer

$$e_j = Y_d - Y_j \neq 0$$

Then we modify the weights $\Delta W_j = \alpha Y_j \delta_j$ so that $\delta_j = Y_j(1 - Y_j)e_j$ then we update the weights

$$W_j\, new = W_j\, old + \Delta W_j \dots\dots\dots 8$$

2. Calculating the error between the hidden layer and the input layer, $e = Y_j - Y_I \neq 0$, then adjusting the weights, $\Delta W_I = \alpha X_I \delta_J$

Where α represents the amount of learning, $\delta_j = Y_j(1 - Y_j) \sum_{i=1}^{N} \delta_j W_i \dots\dots\dots 9$

Then we update the weights, $W_J\, new = W_i\, old + \Delta W_i \dots\dots\dots 10$

Fifth Step:

Repeating the steps in the second step to the fifth step until the required convergence is obtained, which represents the least error (Makridokis, 1998).

The Applied Side

1. **Use Neural Networks to Predict:**

One of the things that encourage the use of neural checks in processing the time series that we are in question is that this series is not of standard specifications (being non-phase), and the process of converting it takes differences that are not always desirable unless the probability distribution of the original series is normal.

The first step in using the program in C++ to obtain the predicted values for the used time series is to specify the inputs for the neural network, where the inputs were data with the number of renal failure patients (women, men, and all).

Where the hidden nodes were identified, which were done through training, i.e. conducting many computer experiments by calculating the following equation:

$$N_{hidden} \leq \frac{N_{train} E_{tolerance}}{N_{pst} + N_{output}} \dots\dots\dots 11$$

- N_{hidden}: represents the number of hidden nodes
- N_{train} : represents the number of training times
- $E_{tolerance}$: represents the amount of probability error
- N_{pst}: represents the number of data on which training was performed
- N_{output} : represents the number of output nodes
- Where the error value was equal to (N_{pst} =0.01), the number of training times (N_{train}=1000) and ($E_{tolerance}$=0.01), and by applying the equation

$$N_{hidden} \leq \frac{5N_{pts}}{N_{pst}+1} \dots\dots\dots 12$$

By examining the series to convert it to a stable state, some models were selected on the data about the arithmetic mean and variance, and both Auto Regression and Partial Auto Regression were examined from different degrees for the purpose of testing.

2. Choose the Number of Hidden Neurons of the Network:

In this test, the appropriate model and its two ranks were used. It was found that the appropriate model for the data and for all (men, women, all together) is ARINA(1,1,1) and after designing the c++ program and using the neural network ARINA(1,1,1) any network Forward propagation to find the standard error of ARE, AE, where the network was trained using the number of hidden neurons, the best number was between (6-7) and Table No. (1) shows the training standard error of ARE, AE and the correlation coefficient

Table No. (1): The amount of standard error and hidden neurons

the infected	ARE	AE	corrl	number of neurons
Men	0.0015	8.953	0.977	7
Women	0.0045	6.930	0.952	2
everyone	0.00125	8.354	0.983	6

The above table shows the value of the error square (AE, ARE), where it was trained (1000) times, and the value of the error square MSE. Thus, the best neurons are (6) for all together, while the male neuron is (7) and the female neuron (2).

3. Practical Application of the Fault Forward Propagation Network:

Where the use of a computer program designed in the C++ programming language to reach prediction values and calculate the statistical parameters, a neural network with forward propagation of error was built for the original observations using hidden nodes and two hidden layers (Nodes) on the principle of training with random weights by applying the forward transmission formula.

$$X_{oi} = seg(X_i) + I * W_i \dots\dots\dots 13$$

Whereas

- X_{oi}: The output from the layer represents the input to the hidden layer.
- $seg(X_i)$: represents the input.
- I: represents repetition.
- W_i: represent weights.

And to calculate the output of the hidden layer according to the formula:

$$OL(J) + seg\left|\sum_{i=1}^{N} x * W[J][i]\right| ------14$$

Whereas

- J : hidden class
- N: the number of observations

As for the output layer, it is calculated by the following formula:

$$O = seg\left[\sum_{i=1}^{3} OL(j.i) * Woi\right] \quad \text{------} \quad 15$$

$$Woi = \eta * z * oL(1,i) \quad \text{------} \quad 16$$

Whereas

- η : Education rate
- OL : The output of the hidden layer.
- Wo : Weights in the output layer.
- Z: It is calculated according to the following formula

$$Z = od - O * seg(out) ------17$$

- od : expected output.
- O: The actual output.

As for the absolute error of the forward transition, the following formula is used

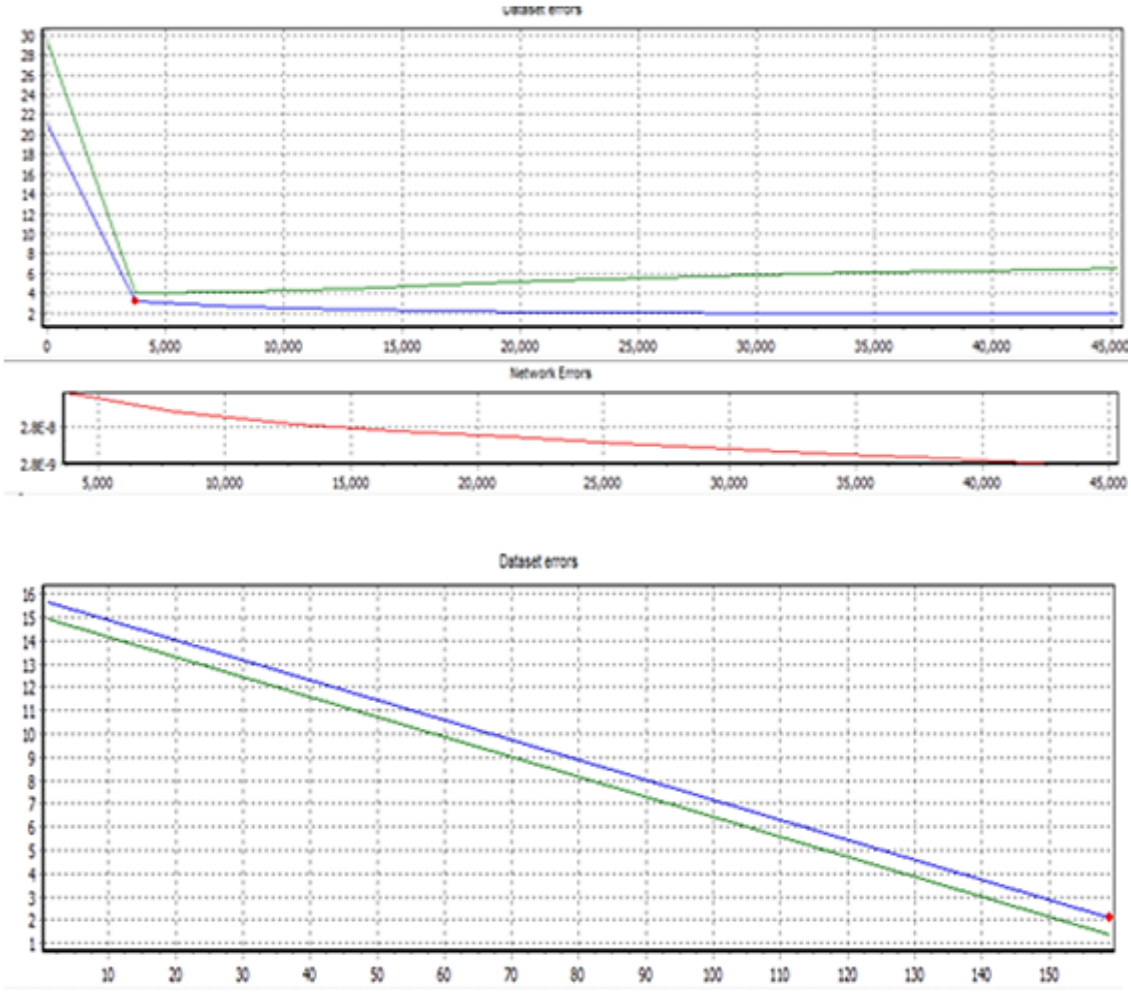
$$e = |od - o| \quad \text{--------(2-6)} \qquad 18$$

The training continues for the network until the specified error value (0.05) is reached. By training the network, prediction values were reached as in Table (2).

Table No. (2): shows the forecast values according to the years 2019-2021

the year / classes	2019	2020	2021
everyone	187	196	204
Men	123	128	130
Women	60	64	70

The table above shows the prognosis values for kidney patients for years (2019-2021). The prognosis values for kidney patients were obtained, as it was found that the values increased for all groups for the three years.



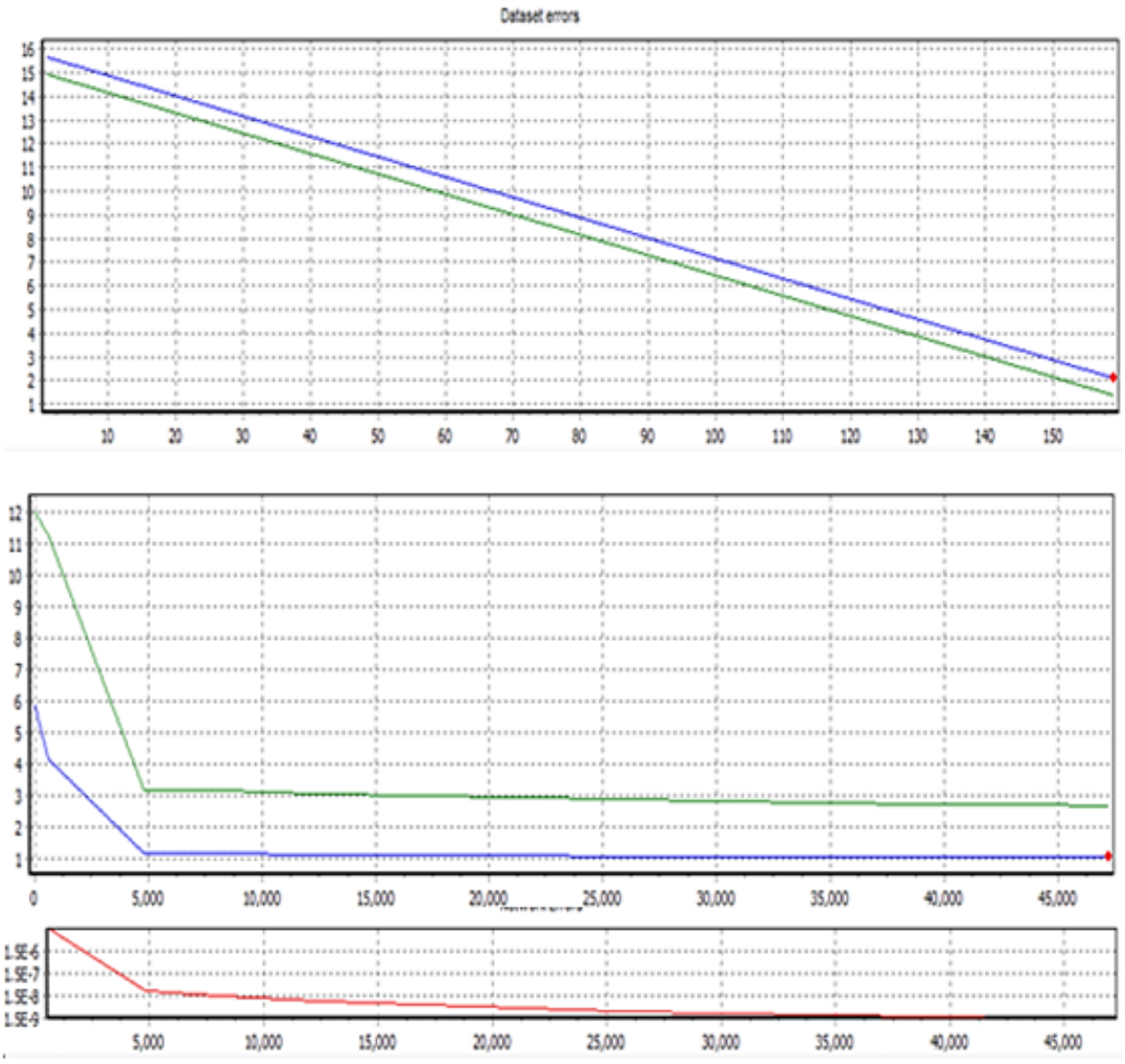


Figure (5): the results of the neural network with data paths

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