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Using Artificial Neural Network Model to Prediction the Number of Peoples Afflicted by the Epidemic of (COVID-19) in Iraq

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Using Artificial Neural Network Model to Prediction the Number of Peoples Afflicted by the Epidemic of (COVID-19) in Iraq

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ABSTRACT

Time-series prediction is an important statistical topic to help researchers in planning and making the right decisions, so this study deals with modern prediction methods, represented by the Artificial Neural Network models, specifically the multi-layered neural network, and the back propagation algorithm has been relied upon several times for training and less selection. A value for error to obtain the best model for describing the data, as well as classic prediction methods such as Box- Jenkins' models, the model was applied to real data represented by the number of people infected with Coronavirus (Covid-19) in Iraq for the period from 2/24/2020 until 3/5/ 2020 On a daily basis, the results showed that future predictions for the number of people infected with Coronavirus began to decline and then stabilized in the period (30-67). The data were analyzed and the results were extracted depending on the statistical program R.

استخدام نموذج الشبكة العصبية الاصطناعية للتنبؤ بعدد المصابين بوباء (COVIED-19) في العراق

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1-Introdaction

Thinking about neural networks began in the last century as Freud gave a philosophical exposure to its general idea. In 1913, Russell implemented a hydraulic device based on the general idea of networks, and in 1943 scientists Warren and Tair invented as a model for calculating the model of calculating neural networks for neural networks based on mathematics and algorithms, and called the threshold logic model that paved the way for much research in neural networks, And the nineties of this century is the real jump in developments. Neural networks have been used in a

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wide range and in many fields such as pattern recognition and image processing from researchers "1" in addition to developing and using them in the field of computing, radar detection and pattern recognition from researchers "2" in dynamic systems from researchers "4" and in the field of medicine from researchers "5" where he treated Intracranial pressure in neural networks was used in ecology from researchers "8" to determine its predictive power of air pollutants. It was developed and used to predict future stock price developments from researchers "9".

The artificial neural network is computational techniques designed to simulate the way in which the human brain performs a certain task by means of massive processing distributed in parallel and consisting of simple processing units. These units are neurons or nodes that have a neurological property as they store experimental information to make it available for use by Adjust the weights. ANN has many advantages but the most famous of them is the fact that it can actually learn by observing a set of data in this way ANN is used as a random function approximation tool. These types of tools help estimate the most cost-effective and ideal methods for arriving at solutions while determining Computing functions or distributions. ANN also takes samples instead of a complete data set to arrive at solutions which saves time and money. As for the disadvantages of ANN, it requires training in order to implement its function, as well as require high processing time. The structure of the neural network is different from the structure of the treatments, so simulation must be used.

This research is aim to use the artificial neural network model to predict the number of peoples afflicted by the epidemic of (COVID-19) in Iraq for the period from24/2/2020 to 3/5/2020 as a daily time series consider the one of new ways also it can be used in different fields, because of the ability to produce

So we divided the paper into three parts the theoretical side, the application side which includes the data analysis and the last part was the conclusions and recommendations.

2. Artificial Neural Networks [3],[7]

An Artificial Neural Network (ANN) is a mathematical model that tries to simulate the structure and functionalities of biological neural networks. Basic building block of every artificial neural network is artificial neuron, that is, a simple mathematical model (function). Such a model has three simple sets of rules: multiplication, summation and activation. At the entrance of artificial neuron the inputs are weighted what means that every input value is multiplied with individual

weight. In the middle section of artificial neuron is sum function that sums all weighted inputs and bias. At the exit of artificial neuron the sum of previously weighted inputs and bias is passing through activation function that is also called transfer function.

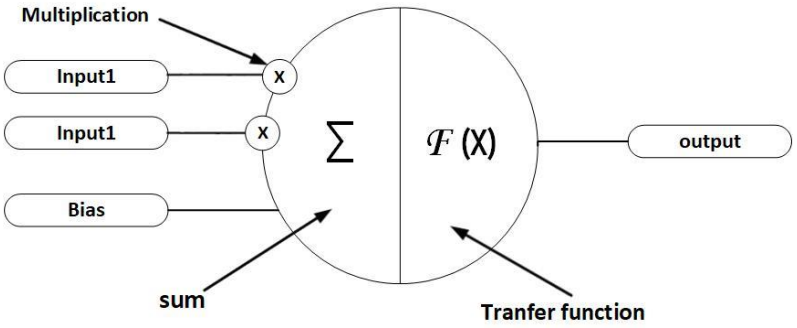


Figure (2-1) Artificial Neuron [3]

The commonly used activations function in the processing nodes are:

1- Linear function

g (x)=x

g (x)=1

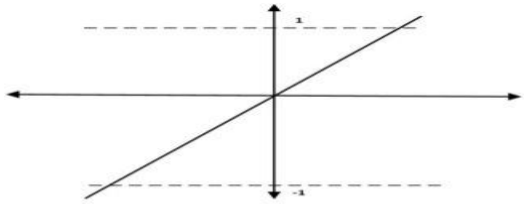


Figure (2-2) shows the Linear function [7]

2- Sigmoid function

g (x)=$\frac{1}{1+e^{-x}}$ $0 > F(X) < 1$

$f`(x) = f(x)[1 - f(x)]$

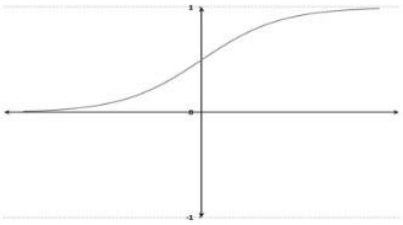


Figure (2-3)shows the Sigmoid function [7]

3- Hardlimiter function

F(x)=0 x<0

F(x)=1 x≥ 0

2-1 Artificial Neural Network Structure [7]

In general ,the ANN consists of three levels:

1-Input level

This level consists of one layer called the input layer ,which consists of a number of units called the input units.

2-Hidden Level

This level consists of one layer or more called the hidden layer(s).every hidden layer has its own processing units called the hidden nodes.

3-Output Level

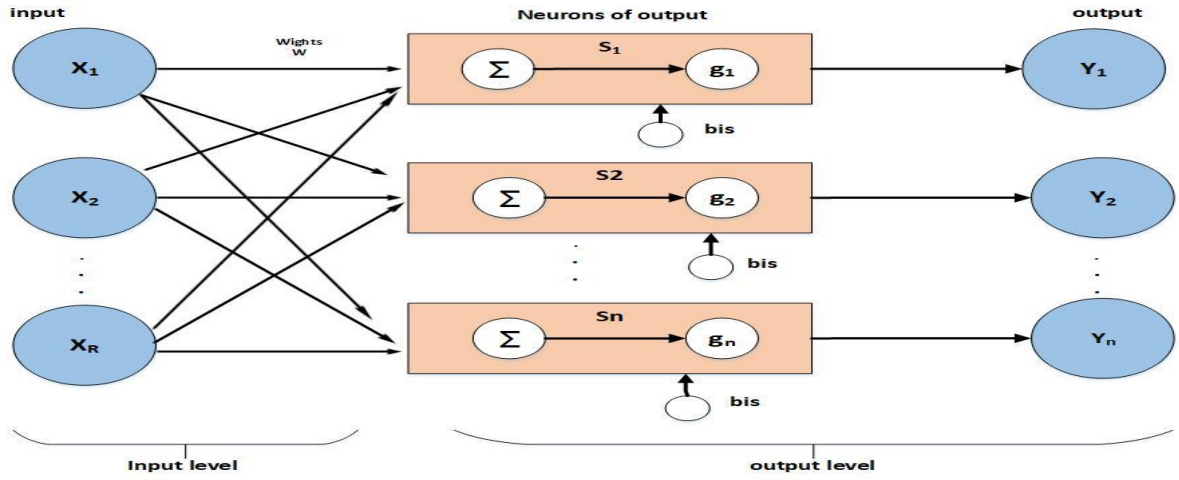
This level consists of one layer called the output layer. This layer consists of a number of processing units called the output nodes.

2-2 Types of Artificial Neural Networks [3],[7],[4]

The ANN can be classified according to the number of the layers into two main types:

1-Single Layer Network

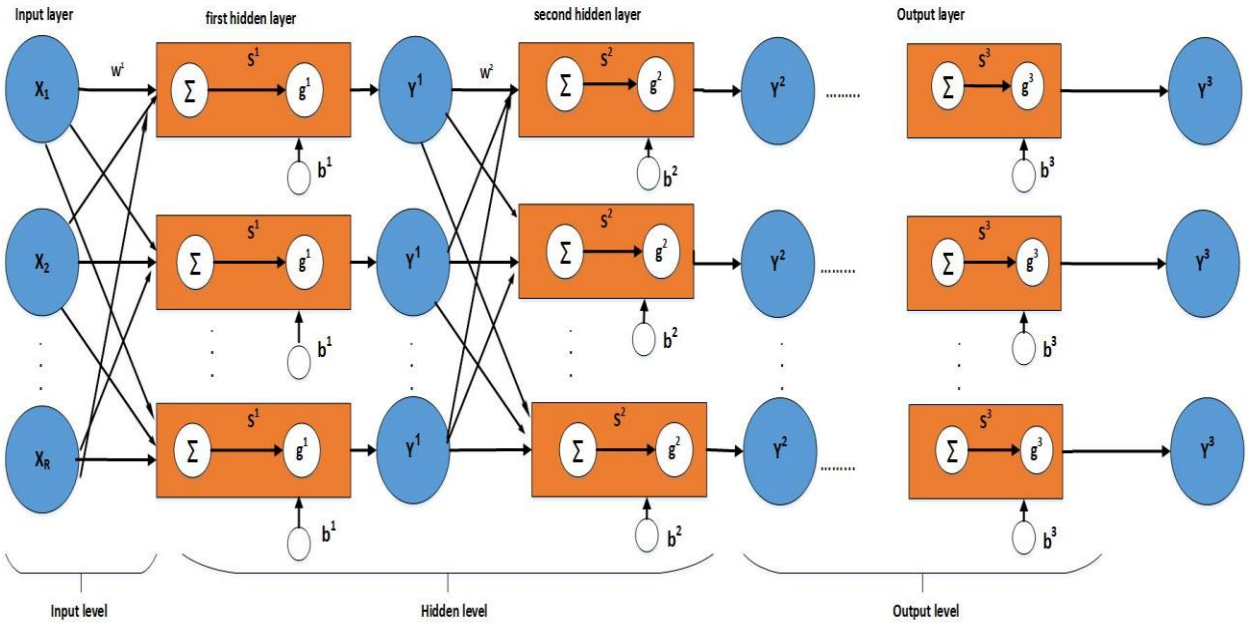
This type of ANN has only input and output layers, which has means that there is no hidden layer and also has one layer of weights that connects the input and output layer.



Finger (2-4) shows the single layer network [from the work of the research]

2-Multi-Layer network

This type of ANN consists of three levels: the input level ,the hidden level and the output level. The hidden level can be one hidden layer of nodes or more. this type of ANN has the ability to solve complex problems that cannot be solve by the single layer network



Figure(2-5) shows the multi-layer network [from the work of the research]

2-3 Training Algorithms [2],[7],[8]

The training in ANN means adjusting the values of the weights and biases in the network, this process is sometime called the learning process. the main aim of the training is to teach the network to do specific tasks.

The training algorithms are divided into three main categories:

1-Supervised Training

The training data is applied as two pairs of vectors :the first pairs the input vector and the second pair is the desired vector. when input vector is applied to the network ,the ANN uses the comparison result(error)to up data the weights of the network and biases in order to reduce the error or the difference between the network output and desired

2-Unsupervised Training

The unsupervised learning is used when there is only an input vector and there is no output vector .in this case, the ANN will figure out the properties of the input values and then stimulate its nodes and weights based on the training algorithm and the input vectors.

3-Reinforcement training

Reinforcement learning is a machine learning technique that sets parameters of an artificial neural network, where data is usually not given, but generated by interactions with the environment. Reinforcement learning is concerned with how an artificial neural network ought to take actions in an environment so as to maximize some notion of long-term reward. Reinforcement learning is frequently used as a part of artificial neural network's overall learning algorithm.

2-4 Backpropagation Algorithm [7]

The Backpropagation algorithm is considered a generalization of the least mean square algorithm, and it is used to train the multi-layer network. the backpropagation algorithm use algorithms among all the supervised training algorithms in neural networks. the training of the neural network by using the Backpropagation algorithm has three main stages:

1-Forward Propagation Stage

In this stage ,the inputs are applied to the network and the weights are randomly generated with small values in addition to identifying the learning rate within a period(0,1).

2-Backward Propagation Stage

The sensitivity is calculated in this stage starting from the last layer and backward to the hidden layer and ending at the input layer.

3-Weights Adaptation

After the forward and backward propagation, the process of adapting weights and biases .

3-The application side

We will use the (ANN) model to predict the number of people that were affected by the epidemic of corona in Iraq for the period from 24/2/2020 to the end of period 3/5/2020 as a daily time series .we get the data from the WHO in Iraq, In order to properly build a neural network, we must understand the problem to be solved, and the input variables that require building the neural network must be determined.

1- Identifying the Input Nodes

In most of the important areas for the design of the neural network, the required nodes are defined at each level. Therefore, the number of input nodes is the same as the number of input variables.

Therefore, in the time series it is difficult to determine the inputs, therefore the BOX-Jenkins method was used to determine the inputs, One of the conditions of BOX-Jenkins must be the stationary series in the medium and the variation as well as it does not contain a general trend and there are no seasonal changes. When drawing the time series represented by the number of coronavirus infections in Iraq, as well as the drawing of Autocorrelations and Partial Autocorrelations We note the following:

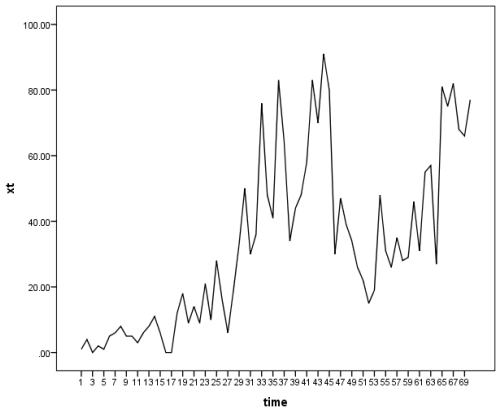


Figure (3-1) Number of people infected with Corona in Iraq

Table (3-1) Shows the Autocorrelations and Partial Autocorrelations of the time series X_t

Series: xt

Lag	Autocorrelation	Std. Error[a]	Box-Ljung Statistic Value	Df	Sig.[b]
1	.771	.117	43.369	1	.000
2	.681	.116	77.765	2	.000
3	.679	.115	112.487	3	.000
4	.544	.114	135.063	4	.000
5	.480	.114	152.928	5	.000
6	.408	.113	166.035	6	.000
7	.376	.112	177.346	7	.000
8	.335	.111	186.483	8	.000
9	.259	.110	192.012	9	.000
10	.208	.109	195.642	10	.000

11	.224	.108	199.938	11	.000
12	.178	.107	202.690	12	.000
13	.082	.106	203.291	13	.000
14	.039	.105	203.426	14	.000
15	.012	.104	203.440	15	.000
16	-.057	.104	203.747	16	.000

a. The underlying process assumed is independence (white noise).

b. Based on the asymptotic chi-square approximation.

Partial Autocorrelations

Series: xt

Lag	Partial Autocorrelation	Std. Error
1	.771	.120
2	.215	.120
3	.262	.120
4	-.192	.120
5	.018	.120
6	-.111	.120
7	.149	.120
8	-.029	.120
9	-.046	.120
10	-.109	.120
11	.177	.120
12	-.059	.120
13	-.140	.120
14	-.159	.120
15	.054	.120
16	-.063	.120

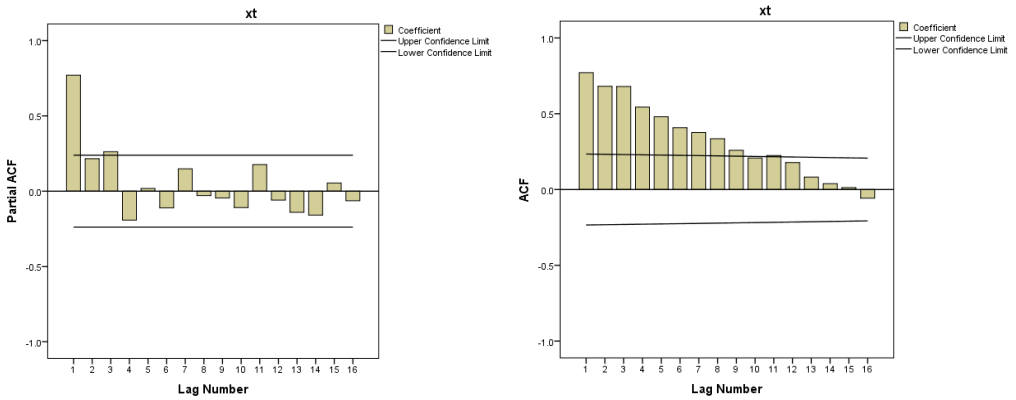


Figure (3-2) Autocorrelations and Partial Autocorrelations

From the above graphs Figure(3-1) (3-2)and table(3-1) , the series is non- stationary in the mean and have high variance and also has a trend. To make the series stationary in the mean and variance we take a difference of lag 1 and take a logarithm transformation , hence the series is become as shown in the following figure (3-3):

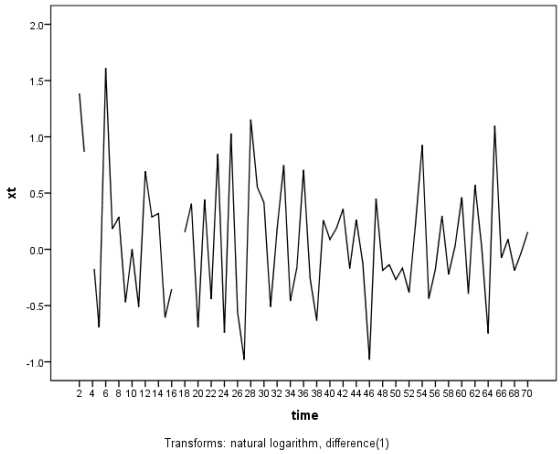


figure (3-3) show the stationary time series

Table (3-2) Autocorrelations and Partial Autocorrelations of the stationary time series

Series: xt

Lag	Autocorrelation	Std. Error[a]	Box-Ljung Statistic Value	Df	Sig.[b]
1	-.333	.120	7.693	1	.006
2	-.064	.118	7.984	2	.018
3	-.068	.117	8.322	3	.040
4	.097	.116	9.025	4	.060

5	.027	.115	9.082	5	.106
6	.056	.114	9.325	6	.156
7	.030	.113	9.394	7	.226
8	-.051	.112	9.598	8	.294
9	-.083	.111	10.156	9	.338
10	-.103	.110	11.041	10	.354
11	.229	.109	15.464	11	.162
12	.045	.109	15.634	12	.209
13	-.066	.109	16.000	13	.249
14	-.129	.108	17.426	14	.234
15	.081	.107	18.001	15	.263
16	-.070	.105	18.446	16	.298

a. The underlying process assumed is independence (white noise).

b. Based on the asymptotic chi-square approximation.

Partial Autocorrelations

Series: xt

Lag	Partial Autocorrelation	Std. Error
1	-.333	.125
2	-.197	.125
3	-.186	.125
4	-.014	.125
5	.042	.125
6	.117	.125
7	.154	.125
8	.063	.125
9	-.073	.125
10	-.241	.125
11	.033	.125
12	.121	.125
13	.079	.125
14	-.039	.125
15	.028	.125
16	-.109	.125

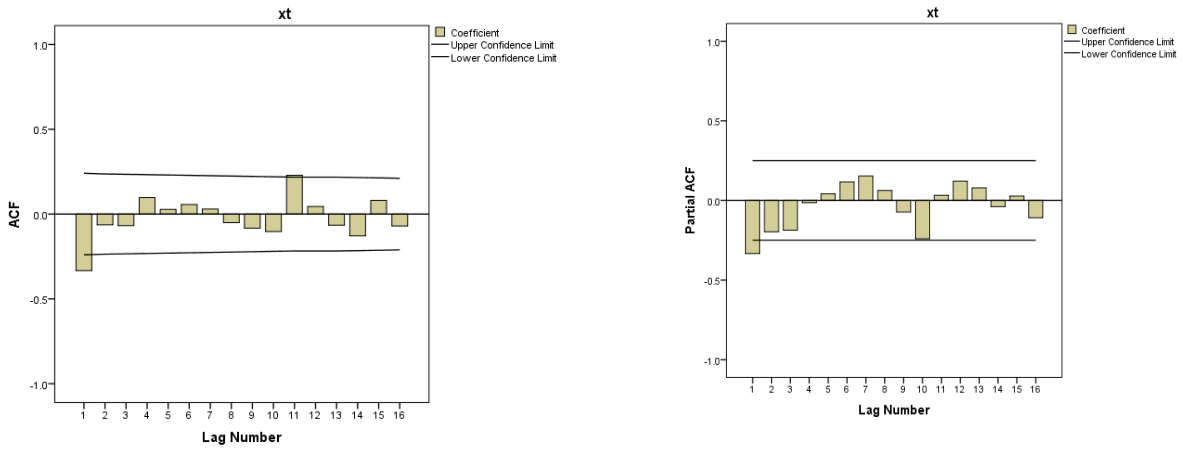


Figure (3-4) show the autocorrelations and partial autocorrelations of the stationary series

From the above figures (3-3) and table (3-2), we note that the series has become stationary and we can identify the model of the time series from figure (3-4), which is ARIMA (1,1,1) and compared it with some of the models close to it to identify the final adequate model that will be used in the artificial neural network and the following table (3-3) appears.

Table (3-3) compare the variants of the ARIMA models to choose the best model

model	Verbal	Model Fit statistics	
		RMSE	Normalized BIC
ARIMA(1,1,1)	Zt	15.293	5.578
ARIMA(1,1,0)	Zt	15.832	5.585
ARIMA(2,1,1)	Zt	14.685	5.558
ARIMA(2,1,0)	Zt	14.779	5.509

Through the above table (3-3) we note that the smallest values for BIC is for the last model ARIMA (2,1,0). As for the MSE ,there is large convergence between the last two models.then we

select the ARIMA (2,1,0) as appropriate model for the studying series that contains the lowest parameters is (2,1,0).

By drawing the residual autocorrelation function, we notice that it is small and random as shown in the table (3-4) and figure (3-5)

Table (3-4) the residual autocorrelation function

Model		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
xt-Model_1	AC	.0	-.026	.0	-.056	.0	-.043	-.001	.0	-.051	-.017	.2	.1	-.036	-.030	-.041	-.019	-.067	.0	-.052	-.024	.0	-.025	.0	.1
	F	30	.0	55	.1	16	.0	.0	16	.0	.1	10	45	.0	.1	.1	.2	.1	84	.1	.1	45	.0	90	09
	SE	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
		22	22	22	23	26	26	26	26	26	26	28	33	35	35	37	39	44	47	48	50	52	52	52	53

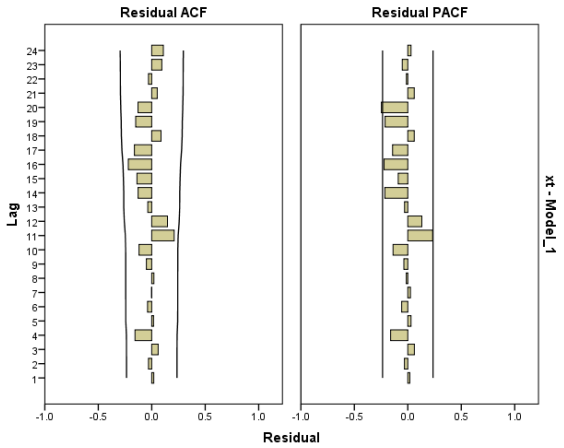


Figure (3-5) the autocorrelations and the partial autocorrelation for the

Table (3-5) ARIMA Model Parameters

					Estimate	SE	t	Sig.
xt-Model_1	xt	No Transformation	AR	Lag 1	-.440	.114	-3.876	.000
				Lag 2	-.367	.114	-3.233	.002
			Difference		1			

The above table (3-5) shows the estimation of model parameters ,where we note that the probable value of the parameters falls within the confidence limits, i.e. it is less than 0.05, meaning that these parameters affect the model.formula form is written as follows:

$$y_t = \emptyset_1 x_{t-1} + \emptyset_2 x_{t-2} + \alpha$$

Thus, the neural network input model has been identified.

2- Identifying the neural network architecture (network structure)

The architecture of the neural network is determined by taking several architectures of the neural network and comparing them using the MSE standard. The architecture that carries the lowest MSE is the best and this process is repeated until the lowest value of the error associated with the training is reached. And when we notice that the error value decreases so that the training process stops where it is done dependence on the architecture that stops the training process.

Through Table No.(3-6), the architecture that bears the lowest MSE is when the network is multi-layered, i.e. it contains an input level and a hidden level contains two layers, the first layer contains four units and the second layer contains three units and the output level and depend on errors Which stops the training, which is (253), the rate of fragmentation is 70% of the training, 30% of the test, momentum factor of 0.9, and the number of cycles is 1000 cycles. Figure (3-6) shows the structure or architecture of the artificial neural network .

Table (3-6) Neural Network architectures

Number of hidden layer	4x2	4x3	4x5	4x4	3x4	3x3
MSE	285	253	329	451	283	392

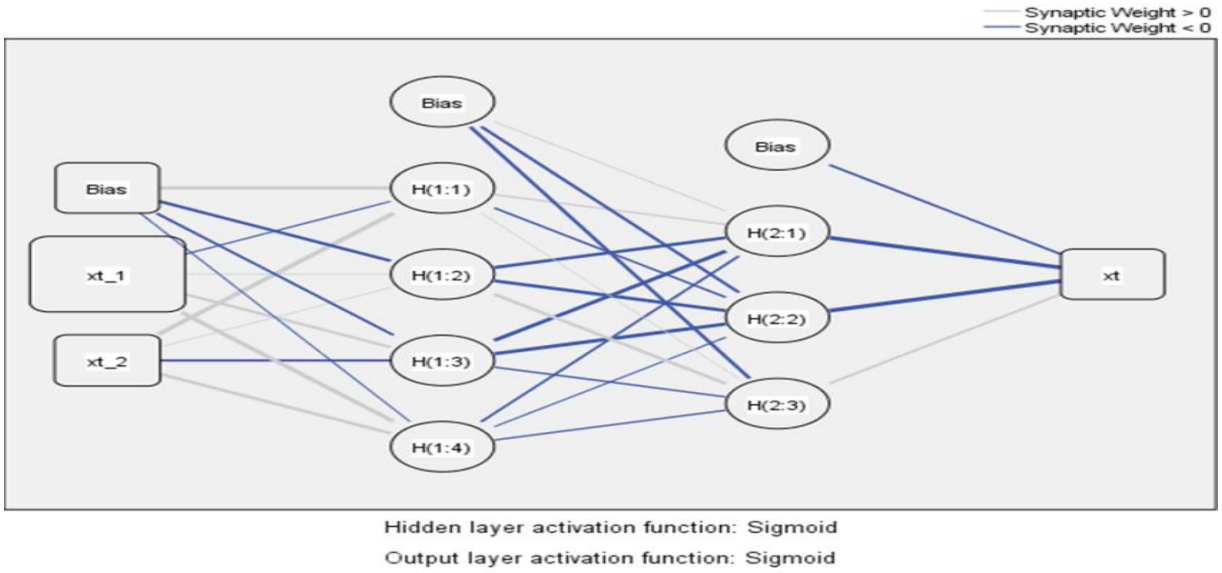


Figure (3-6) The final artificial neural network model

3- Activation Functions

The sigmoid activation function was used in the hidden layer and output layer.

4- Artificial neural network weights

After training the neural network using the pagpropagation algorithm, weights are updated and Table No(3-7) shows weights of the artificial neural network model.

Table (3-7) shows the weights of the neural network units

Parameter Estimates									
Predictor		Predicted							
		Hidden Layer 1				Hidden Layer 2			Output Layer
		H(1:1)	H(1:2)	H(1:3)	H(1:4)	H(2:1)	H(2:2)	H(2:3)	xt
Input Layer	(Bias)	.569	-.385	-.279	-.066				
	xt_1	-.094	.042	.363	.615				
	xt_2	.675	.031	-.308	.478				
Hidden Layer 1	(Bias)					.051	-.325	-.342	
	H(1:1)					.126	-.134	.010	
	H(1:2)					-.491	-.506	.410	
	H(1:3)					-.521	-.559	-.108	
	H(1:4)					-.186	-.068	-.097	
Hidden Layer 2	(Bias)								-.249
	H(2:1)								-.724
	H(2:2)								-.753

	H(2:3)								.289

5- Diagnostic test for artificial neural network model

Through training the neural network and determining predictive values the real time series was draw with predictive values to determine the behavior of the series.it is clear from the drawing that there is an increase in the number of injuries, but it stabilizes at a certain time and is at the period (30-67) the figure (3-7) shows that:

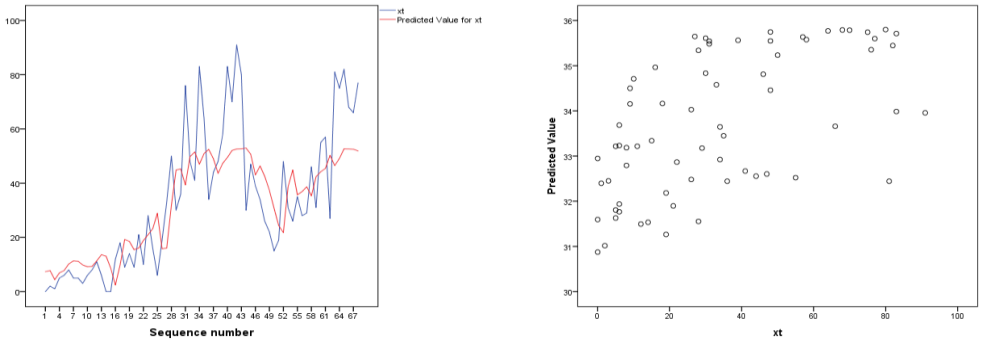


Figure (3-7) (Plot real values with predictive values)

4. conclusions

The most important conclusions reached through the study are :

1- The time series of the number of people that inflicted with COVIED-19 in Iraq is a non-stationary with the mean and non- stationary in the variance, as well as it has a trend and high volatility as shown in figure (3-1) (3-2) table (3-1)

2- The Box-Jenkins methodology showed that the best model to represent the date is the ARIMA (2,1,0) model.

3- Based on the average square error, the best neural network architecture is among several architectures when the network contains an input level and a hidden level that contains two layers the first layer contains four units and the second layer contains three units and contains the output level (multi-layer network) As shown in Figure (3-6).

4- After training the neural network, predictive values were obtained and plotted with real values as shown in figure(3-7).

5. Recommendations

We conclude the following:

1-The recommendation is directed to the Ministry of Health and the departments concerned with using the neural network model that has been reconciled with the data used in the study to predict future infections in order to take the necessary measures .

2- recommends the use of other statistical methods such as spectral analysis models in time series or models of parameter regression and other models.

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