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Forecasting the Number of (Infected, Recovered, Death) For COVID-19 in Iraq by Using Neural Network Models

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Abstract

Predicting the diseases caused by viral infections is a complex medical task as many real data consisting of different variables must be used. As it is known, COVID-19 has created a great crisis in all countries of the world because of the repercussions it has left and will leave behind, it is necessary to find a way to explain the spread of this virus by relying on data of many infected, deceased and recovered people, so artificial neural networks were used (ANN) to predict the numbers (infected, deceased, recovered) of the COVID-19 pandemic, because the idea of \u200b\u200bthe work of neural networks is the process of simulating data to reach a model for this data for the purpose of analysis, classification, prediction or any other treatment without resorting to a proposed model for these data, as An appropriate neural network was designed, as well as an automatic algorithm for teaches and trains the network to reduce the error coefficient to the lowest level, Forecasting was also carried out in nonlinear models, which proved that neural networks are fully capable of predicting. One of the most important conclusions reached by the research is the appropriateness of the Radial Basis Function Neural network (RBFNN) model to modeled and to forcasting of the data of the numbers of infected, deceased and recovered patients for the Corona virus in Iraq for the period from (1/22/2020-31/7/2021) and this is what was clarified by the values of MSE, RMSE AND R2, addition that The predictive

values were very close to the true values, and this confirms that the RBFNN model is very suitable.

Introduction

Coronaviruses are a group of viruses that cause respiratory illnesses ranging in severity from the common cold to fatal pneumonia. The newly discovered COVID-19 is called severe acute respiratory syndrome coronavirus 2 (SARS-CoV2). Early cases of COVID-19 in Wuhan- China, have been linked to a live animal market, which indicates that the virus was transmitted to humans from animals being sold as food. COVID-19 infection spreads from person to person through airborne droplets from an infected person (within 2 meters for 15 minutes or more over 24 hours), but the virus may spread over larger distances or stay in the air for longer under Certain conditions[1,2]. In general, the virus is usually spread from an infected person who shows symptoms, but it may also spread from infected people before they develop symptoms, or even from infected people who do not show any symptoms. The risk of severe illness and death from COVID-19 increases with Older age, smokers, and people with other serious medical conditions, such as cancer, heart, lung, kidney, or liver disease, sickle cell anemia, diabetes, obesity, or disorders that weaken immunity.

Coved-19 has spread widely all over the world, in Iraq, more than 1494,760 people have been infected, which has resulted in (18,938) of deaths from its beginning in the year 22/1/2020-31/7/2021, and therefore the necessary measures must be taken in order to limit the spread of it and for this purpose, the prediction using models Dynamic statistics, including neural network models, can help health systems in allocating medical resources to face the escalation of confirmed cases of this virus. As for predicting cases of recovery and deaths, it gives a clear picture of the different health systems that the measures taken are correct or not.

Artificial neural networks (ANN)

Artificial neural networks (ANN) simulate both linear and non-linear models, in non-linear models it is done by non-linear processing of the inputs where neural networks select the appropriate model, and they are found especially in biological neural models. The way neural networks work is similar to the human mind through training to acquire and store knowledge through massive parallel

processing that takes place inside the so-called neuron, and therefore it is a mathematical model , first in which data is first entered that multiplies with the individual weight, i.e. the inputs are weighted, and then collect the inputs are Weighted and bias calculation through the transfer function before outputting the results[3-5], and Figure (1) shows the components of ANN.

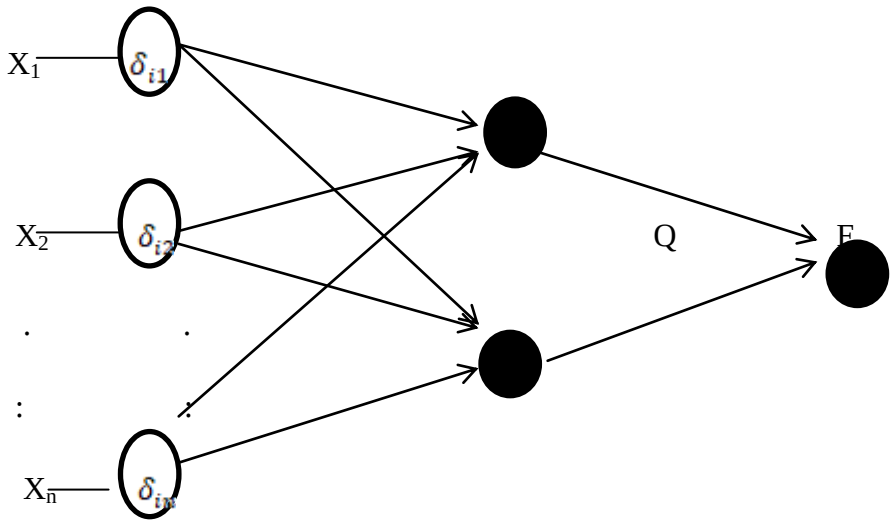

Figure 1: The components of Artificial Neural Networks.

So the neuron can be represented by the following equation[6-8]:

(1)	$Y_k = f\left[\sum_{i=1}^{k} \delta_{iz} X_i + QZ\right]$

Where:

- $x_i(z)$: represent the input values.
- $\delta_i(z)$: The weights of the neuron z.
- Qz : is bias.
- $y_i(z)$: represent the output values.
- k : represent the number of basis functions.

Neural networks consist of two models. Multilayer Perceptron Network (MLP) models are commonly used in various applications, and their modules are arranged in a multi-layer structure

called Feed Forward Network (FFN). And radial basis function (RBF) models, which is the second model of neural network models that have been suggested by many researchers, and they are good models for modeling nonlinear data, Its difference from MLP is that it does not depend on the weighted sum in calculating the outputs of hidden units , but rather depends on the following equation[8-10]:

(2)	$F_i = R\left(\frac{\|X - \vartheta_i\|}{\sigma^2}\right)$

whereas: F_i: hidden unit product, i=(1,2,…,I)

X: input unit.

ϑ_i: parameter vector.

R: a(kernel) which is strictly positive radially symmetric function.

σ^2: is The parameter which represent the width of the receptive field in the input space from unit i.

Here, we find that the distance $\|X - \vartheta_i\|$ when it is smaller than σ^2it has clear values .Radial functions R(.) are among those distinct functions whose response is decreasing or increasing in order with the distance from a central point, have a variable of many formula expression for example(B-Spline , Cauchy ,inverse- multiquadric and Gaussian)RBF. However, the most common and used is a Gaussian function, which has the following formula:

(3)	$R(\emptyset) = \exp\left(-\frac{\emptyset^2}{2}\right)$

Therefore, the weights that connect the hidden layer and the output layer determine the outputs of the radial basis function, which in turn determines the outputs as a linear combination of the outputs of it , which is shown in the equation below:

(4)	$Y_L(X) = \sum_{i=1}^{I} \delta_{Li} F_i(X)$

This linear combination is one of the easy models in mathematical analysis, especially when using the method of least squares to find a solution to part of the supervising learning problems, then it is possible the optimal weight values for a set of equations that include training set can be solved and derived as follow:

The training set can be for q pairs represented by the following equation[10]:

(5)	$\aleph = \{(X_j - Y_j^{\wedge})\}_{j=1}^{q}$

The least squares method works to reduce the sum of the squares of the error to a minimum, according to the following equation:

(6)	$\emptyset = \sum_{j=1}^{q} (Y_j^{\wedge} - Y_j)^2$

To minimize the cost function, the model weights are added as a prerequisite to the sum of the squares of the error as shown in the following equation:

(7)	$w = \sum_{j=1}^{q} (Y_j^{\wedge} - Y_j)^2 + \sum_{i=1}^{k} \tau_i \delta_i^2$

Whereas $\{\tau_i\}_{i=1}^{k}$ are regularization parameters. Then we derive the cost function with respect to i [th] weights:

(8)	$\frac{\partial w}{\partial \delta_i} = 2\sum_{j=1}^{q}(Y_j^{\wedge} - Y_j) \quad \frac{\partial Y_i}{\partial \delta_i} + 2\tau_i \delta_i$

Since we know that:

(9)	$\frac{\partial Y_i}{\partial \delta_i} = F_i(X_j)$

Substituting this into equation(8) equating the result to zero we get:

(10)	$\sum_{j=1}^{q} Y_j F_i(X_j) + \tau_i \delta_i^{\wedge} = \sum_{j=1}^{q} Y_j^{\wedge} F_i(X_j)$

According to the above equation, we have k of linear equations which represents a constraint, any group of unknowns, therefore the system of equations above has a single solution.

Statistical Analysis

In this research, we relied on data taken from the global website for Corona pandemic data, representing the number of injuries, recovery and death in Iraq, for the period from (22/1/2020-31/7/2021), Where we note that the number of cured of the disease was high (1494,760) compared to the number of deaths in Iraq, where it was (18,938). By applying the radial neural network model, the following results were obtained:

Table No. (1)The number of hidden units

Model Summary

Training	Sum of Squares Error		4.023
	Average Overall Relative Error		.007
	Relative Error for Scale Dependents	confirmed	.006
		recovered	.011
		death	.004
	Training Time		00:00:00.285
Testing	Sum of Squares Error		3.787[a]
	Average Overall Relative Error		.014
	Relative Error for Scale Dependents	confirmed	.004
		recovered	.033
		death	.002

We note that the sum of the squares of the training error was 2.209 with an average relative error of 0.004, while the sum of the squares of the error for the test was 1.069, We also note that “there is little difference between the average Overall Relative Error, in the training and testing phases, where: The best number of hidden units results in the smallest error in the test data.

Table No. (2) Parameter Estimates

Predictor	**Predicted**	
	Hidden Layer[a]	**Output Layer**

		H(1)	H(2)	H(3)	H(4)	H(5)	H(6)	H(7)	H(8)	H(9)	confirmed	recovered	death
Input Layer	**Time_id**	-1.281	-.711	-.392	-.018	1.577	1.013	1.725	1.331				
Hidden Unit Width		.266	.064	.127	.104	.212	.072	.103	.019	.082			
Hidden Layer	**H(1)**										-1.020	-.975	-1.330
	H(2)										-.926	-.925	-1.005
	H(3)										-.601	-.615	-.330
	H(4)										-.105	-.094	.311
	H(5)										.215	.339	.644
	H(6)										2.009	2.234	1.413
	H(7)										.964	1.047	.963
	H(8)										2.555	-1.517	1.666
	H(9)										1.430	1.661	1.186

Table No. (2) Displays the synaptic weights that were calculated using the training data set, accordingly, the final form of the radial neural network was obtained, as in Figure No. (1).

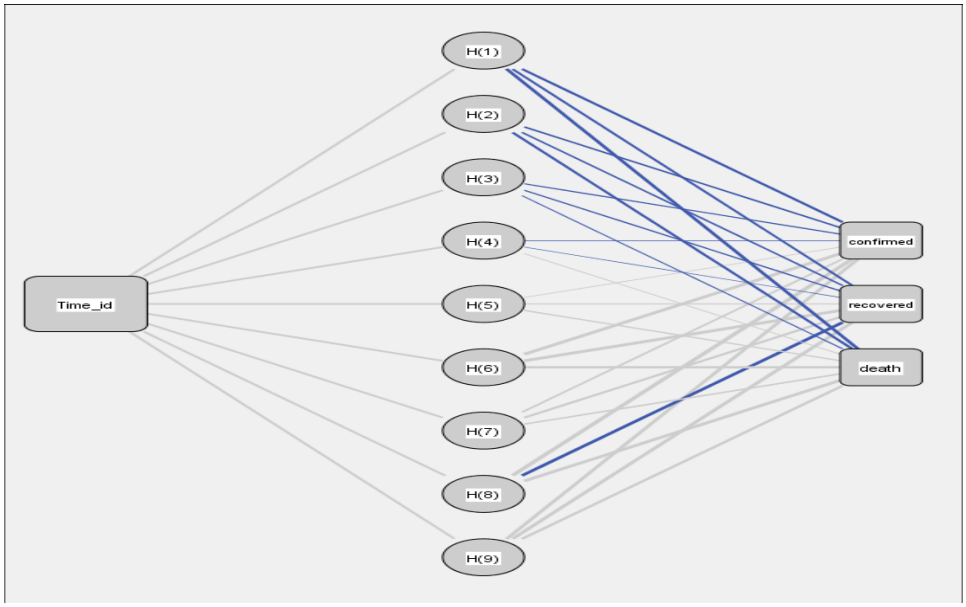

Figure No. (1) The radial neural network

The structure of radial neural networks was used to predict the number of cases of injury, recovery and death in Iraq, compared to the cases recorded for the period from (22/1/2020 to 7/31/2021). The results showed that there was little difference between the expected number, and the number recorded for the three series, and as shown in Table No. (3) and graphs (2,3,4), respectively.

Table No. (3) of the predictive values of the numbers of injured, recovered and deceased during the Corona pandemic in Iraq

Forecast	***Forecast***	***Forecast***
1.27267E6	1.15742E6	19558.2
1.27546E6	1.15998E6	19597.1
1.27825E6	1.16255E6	19636.1
1.28104E6	1.16511E6	19675.0
1.28383E6	1.16768E6	19714.0
1.28662E6	1.17024E6	19752.9
1.28941E6	1.17281E6	19791.9
1.2922E6	1.17537E6	19830.9
1.29499E6	1.17794E6	19869.8
1.29778E6	1.1805E6	19908.8

1.30057E6	1.18307E6	19947.7
1.30336E6	1.18564E6	19986.7
1.30615E6	1.1882E6	20025.6
1.30894E6	1.19077E6	20064.6
1.31173E6	1.19333E6	20103.6
1.31452E6	1.1959E6	20142.5
1.31732E6	1.19846E6	20181.5
1.32011E6	1.20103E6	20220.4
1.3229E6	1.20359E6	20259.4
1.32569E6	1.20616E6	20298.3
1.32848E6	1.20873E6	20337.3
1.33127E6	1.21129E6	20376.3
1.33406E6	1.21386E6	20415.2
1.33685E6	1.21642E6	20454.2
1.33964E6	1.21899E6	20493.1
1.34243E6	1.22155E6	20532.1
1.34522E6	1.22412E6	20571.0
1.34801E6	1.22668E6	20610.0
1.3508E6	1.22925E6	20649.0
1.35359E6	1.23182E6	20687.9
1.35638E6	1.23438E6	20726.9
1.35917E6	1.23695E6	20765.8
1.36196E6	1.23951E6	20804.8
1.36475E6	1.24208E6	20843.7
1.36754E6	1.24464E6	20882.7
1.37033E6	1.24721E6	20921.7
1.37312E6	1.24977E6	20960.6
1.37591E6	1.25234E6	20999.6
1.3787E6	1.2549E6	21038.5
1.38149E6	1.25747E6	21077.5
1.38428E6	1.26004E6	21116.4

1.38707E6	1.2626E6	21155.4
1.38986E6	1.26517E6	21194.4
1.39265E6	1.26773E6	21233.3
1.39544E6	1.2703E6	21272.3
1.39823E6	1.27286E6	21311.2
1.40102E6	1.27543E6	21350.2
1.40381E6	1.27799E6	21389.1
1.4066E6	1.28056E6	21428.1
1.40939E6	1.28313E6	21467.1
1.41219E6	1.28569E6	21506.0
1.41498E6	1.28826E6	21545.0
1.41777E6	1.29082E6	21583.9
1.42056E6	1.29339E6	21622.9
1.42335E6	1.29595E6	21661.8
1.42614E6	1.29852E6	21700.8
1.42893E6	1.30108E6	21739.8
1.43172E6	1.30365E6	21778.7
1.43451E6	1.30622E6	21817.7
1.4373E6	1.30878E6	21856.6

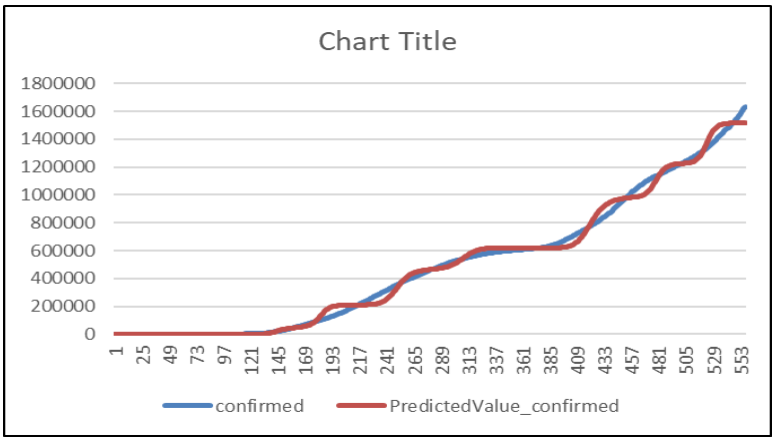

Figure No. (2) Predicting the number of injuries and comparing it with the real values

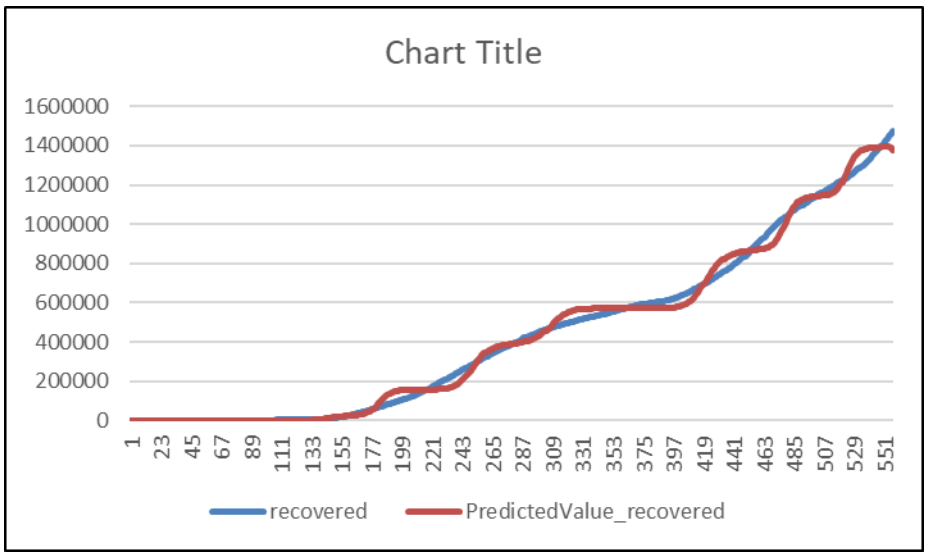

Figure (3) The chart for predicting the numbers of recovery and comparing it with the real values

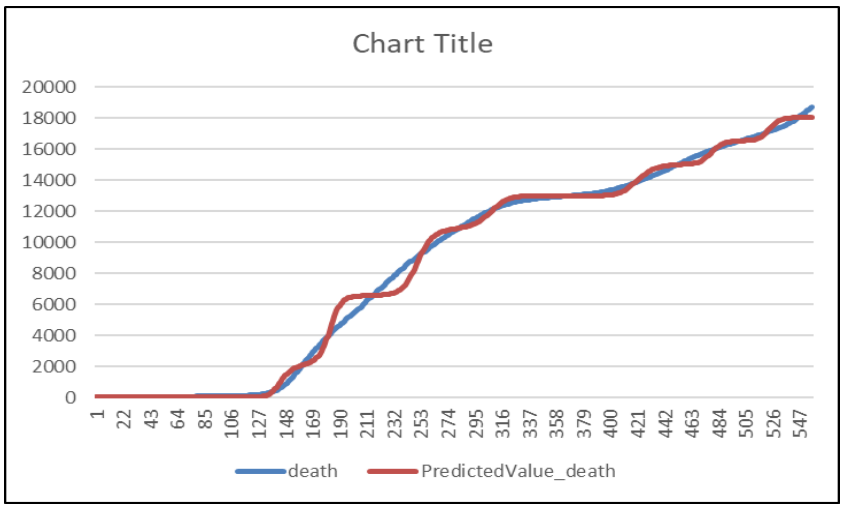

Figure No. (4) The chart for predicting the numbers of deaths and comparing it with the real values

The statistical measures were calculated, and as shown in Table (4), and these measures confirm that the radial neural network training was the ideal model in predicting the numbers of injuries, recovery and deaths in Iraq.

Table No. (4) Comparison criteria

Model	**R Square**	**MSE**	**RMSE**
confirmed	92.428	16486660618	125550
recovered	91.505	15860043224	121501

death	95.097	2021664.498	1392.45

4:- The Conclusions and recommendations

1:- Radial neural networks have the ability to predict the numbers (injury, recovery, and death), through multiple inputs to estimate the optimal size.

2:- Neural networks work to reduce and regulate the weights of the inputs, to improve the outputs by a large percentage, which makes them a great ability to predict global disease infections.

3:- The cases recorded in Iraq are inaccurate, due to the lack of documentation of injuries in hospitals, which led to the convergence of the real values of the three series (injuries, recovery and death) with the predictive values.

4:- We recommend the use of other factors that affect the infection of the corona pandemic, to reach solutions to limit the spread of the disease and reduce injuries.

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