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Predicting Date Production in Iraq Using Recurrent Neural Networks RNN

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Abstract: Artificial intelligence methods play an important role in predicting future values of time series and thus help in setting economic and social development plans. The study aimed to predict the production of dates in Iraq using recurrent neural networks, based on the production of dates in Iraq for the period from 2002-2021. The appropriate prediction model was chosen based on the MSE, MAPE, and MAE error measures. Recurrent neural networks that used the TRAINBR training function and the Purlin function were adopted to predict the production of dates in Iraq, which gives the lowest error value for the MSE, MAPE, and MAE error measures.

Keywords: Production of Dates, Time Series, Recurrent Neural Networks.

1. INTRODUCTION

In many countries, including Iraq, the agricultural sector plays a significant role in the economy. It provides a living for a sizable section of the populace and serves as a supply of raw materials for several manufacturing companies. It is one of the most significant crops both economically and in terms of food.

Iraq stands out for producing a wide variety of dates, making it one of the world's leading producers of dates compared to other producing nations. Date production has experienced significant fluctuations in recent years, due to political unrest, a lack of strong agricultural policies and plans in Iraq, disease outbreaks affecting a large number of palm trees, and falling date prices relative to production costs [1]. in addition, there isn't a marketing organization to acquire dates and deliver them to manufacturers who use them as raw materials, lackluster overseas markets for the export of dates [2]. Therefore, it is necessary to make decisions and implement policies about Iraq's future date production, as one of the key indicators used by decision-makers is the ability to anticipate future values through the analysis of past date

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production data, or "time series." The term "time series" refers to a collection of observations made by phenomena at frequently equal intervals of time. It has two variables: the value of the phenomena is the dependent variable, and time is the independent variable. Studying a time series aims to quantify the changes that a phenomenon experiences over time to understand its causes, effects, and potential values [3]. This is crucial information for making decisions about future planning and for estimating the phenomenon's future value based on an analysis of the phenomenon's historical development. There are many statistical methods and artificial intelligence that are used to predict future values by studying time series, but artificial neural networks, in particular RNN, are among the methods that have received a lot of interest in studying time series in recent years [4]. Therefore, this study came to predict the future values of date production through recurrent neural networks, which help in making decisions that will increase production efficiency and productivity in addition to activating the performance of marketing functions, opening an external market to receive surplus dates [5].

2. Research Problem

Iraq is distinguished from other countries of the world by producing 600 varieties of dates, the most important of which are Al-Khastawi, Al-Khadrawi, Al-Zahdi, and Al-Sayer...which are distinguished by the intensity of their production. Therefore, date production in Iraq plays an important role in the overall economy of Iraq through its contribution to meeting the need of local markets for dates for human and animal consumption and in the manufacture of various products and exporting surplus parts abroad. Forecasting the future values of date production plays a role in investment decisions in the date sector, and also gives a clear picture to formulate policies, develop plans, and implement programs to develop the date sector. Based on the above, the research problem lies in the extent of the possibility of building a model based on recurrent neural networks that help the economic planner in developing and developing date production in Iraq and maximizing the financial return from it.

1. Importance of the Research: The importance of the research stems from the use of recurrent neural networks in predicting the future of date production as one of the modern methods of high-quality prediction and directing the research results in making decisions and policies that concern the future of date production in Iraq.

2. Research Objective: The research aims to predict the production of dates in Iraq using recurrent neural networks.

3. ARTIFICIAL NEURAL NETWORKS

3.1 Concept of Artificial Neural Networks

Artificial neural networks are one of the techniques of artificial intelligence, their idea is to try to simulate the biological cells of the human brain and benefit from their working mechanism in wide fields, as neural networks are used today in the fields of classification, analysis, and prediction. Recent studies have focused on using neural networks to predict various purposes [6]. Neural networks have special advantages in prediction because of their adaptability and capacity to manage nonlinear data, which traditional methods have failed to do. Artificial neural networks can be defined as mathematical tools that can create a non-linear representation between variables [7]. They are systems for processing information in a manner that mimics

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biological neural networks [8]. It uses learning methods and adjusts the links (weights) to create the best consistency between inputs and outputs [9].

3.2 Architecture of Artificial Neural Networks

An artificial neural network (ANN) is a network composed of a network of interconnected nodes that resemble neurons [10] . It is made up of multiple interconnected artificial neurons that work together to process vast volumes of data and do incredibly complex calculations at the same time using input data. Sequential computations and trial-and-error processes provide the outputs of ANN operations, which are not predicated on specific rules [11].

The neural network consists of four main interconnected sections [12]:

- **Input layer**: It is the first layer. Its function is to receive the internal signal (data), where it multiplies it by the binding weights (rational numbers between 0 and 1), and then sends the input data to the sum function.
- **Sum function**: It combines the signals coming from the input layer into one signal to send it to the activation function.
- **Activation function**: Its function varies from one cell to another depending on the function used, as it places the input values in the range (0-1) to facilitate the training process in the neural network.
- **Output layer**: This layer receives the outputs of the activation function, and performs some operations on it to obtain the required outputs.

Figure 1 represents the general model of ANN:

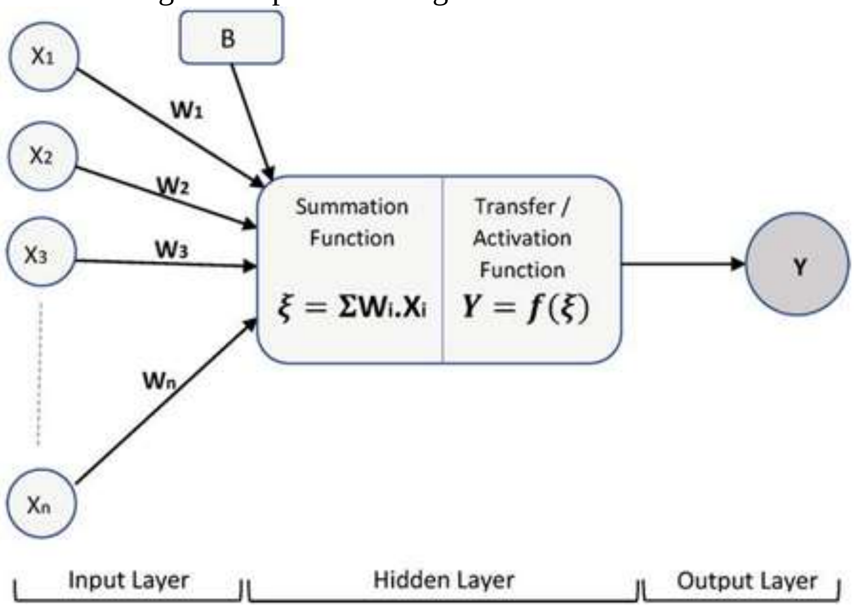

Figure 1: a general model of ANN [13].

3.3 Types of Artificial neural networks: Many artificial neural networks differ in their architecture, mechanisms, and purpose:

- Multilayer Perceptron.

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- Radial Basis Functional Neural Network.
- Convolutional Neural Network.
- Recurrent Neural Network.
- LSTM – Long Short-Term Memory.
- Sequence to Sequence Models.
- Modular Neural Network.

3.4 Recurrent Neural Network:

Recurrent neural networks (RNNs) are feed-forward network derivatives that incorporate a hidden state and employ past network outputs as inputs. An RNN can process input sequences by processing previous states that it has memorized [14].
Table 1 shows the difference between network RNNs and other artificial neural networks

Table 1: the difference between RNNs and other artificial neural networks

	difference
feedforward and CNNs	RNN neural network takes into account the time dimension
Some types of neural network algorithms	The output of an RNN depends on the previous elements, while some neural networks assume that the inputs and outputs of the model are independent of each other.

The basic structure of RNN is shown in the figure (2).

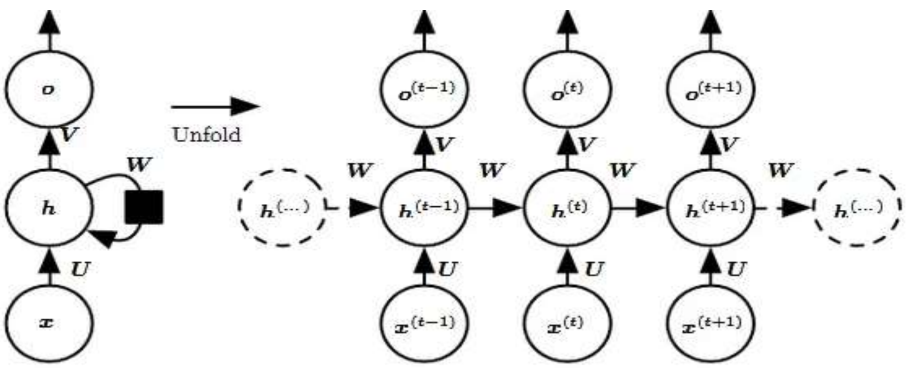

Figure (2): structure of RNN [15].

From Figure (2), Dilmegani pointed out that [15]:

- Layer x: is the input layer, where x(t) is denoted by the model inputs in time interval t.
- The middle layer h: consists of multiple hidden layers that have their activation functions. h(t) denotes the hidden state of the network at time step t. The hidden states act as a "memory" for the model and are calculated based on the current input x(t) and the previous hidden state h(t-1).
- The upper layer o: is the output layer. o(t) represents the model output in time interval t. The current output is determined by the current input, x(t), and the current hidden state, h(t).

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- The parameters (U, V, W) represent the weights between inputs, hidden states, and outputs that express the extent of influence between them.

4. RESULTS AND DISCUSSION

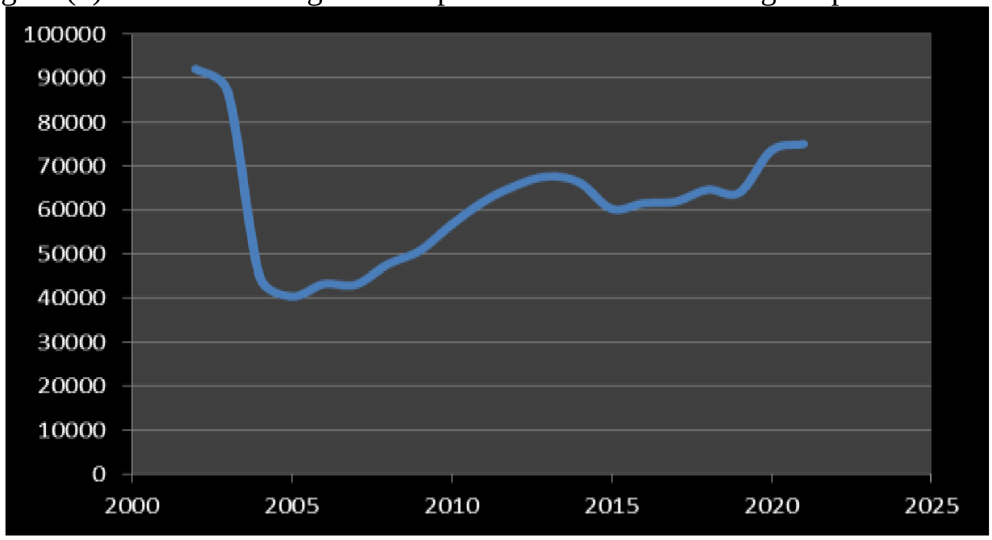
The study aims to forecast and predict the production of dates in Iraq using recurrent neural networks, based on the annual time series data for the period (2002-2020) as in Table (2).

Table (2): production of dates during the period (2002-2020)

Production of Dates (Tons)	Year	Production of Dates (Tons)	Year
65545	2012	91947	2002
67611	2013	86839	2003
66245	2014	44838	2004
60235	2015	40403	2005
61521	2016	43236	2006
61883	2017	43086	2007
64619	2018	47632	2008
63932	2019	50700	2009
73535	2020	56683	2010
75024	2021	61918	2011

Source: Iraqi Statistical Group 2020-2021 https://cosit.gov.iq/ar/

Figure (3) shows the changes in the production of dates during the period studied.



From Figure (3), it is clear that there is a general increasing trend for the period from 2005 to 2013, to return and decline until 2015, then rise again until 2021.

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Forecasting the Production of Dates Using Recurrent Neural Networks:
The MATLAB program was used in the forecasting process using the recurrent neural networks, due to the importance of this program and its wide applications in many vital areas, including forecasting.

Steps of Forecasting the Production of Dates Using Recurrent Neural Networks:
We follow the following steps using the MATLAB program and through the tool (tool):

1. **Data Entry**: the data is entered in the form of an input data beam (3 time delays are taken).
2. **Target Data:** enter the desired output beam.
3. Divide the production of date data into three sections:

- Training stage: 70% of the sample size (training group), to train the network until it reaches the stability stage, and the stability stage means - adjusting the network according to error - i.e. decreasing the MSE error measure to the specified value of the significance level 0.05 at the end of the process, the network is stabilized, that is, the network is ready for the testing phase.
- Test phase: 15% of the sample size (test group), from which we obtain the output result calculated by the network.
- The verification or stopping stage, which is 15% of the sample size (as it helps the network to achieve the stopping condition, which ends the network's work so that it does not continue to repeat indefinitely since the required error measure has been reached). It is possible to modify the previous percentages from one network to another while maintaining a high percentage of the training set data.

4. Choose the type of artificial neural network used in prediction.
5. **Selection of error measure and use of training algorithm for the network used:**

- The error metric RMSE was chosen, which is a standard error metric used in most types of artificial neural networks.
- The selection of weights and white noise is done randomly, depending on the selected network tools. - Choosing the network training algorithm, where (TRAINLM, and TRAINBR) were chosen from the MATLAB program options. This option represents a training algorithm (Levenberg-Marquardt backpropagation), which is an algorithm that relies on error-progression learning and adjusts weights and bias weights based on the Levenberg-Marquardt technique. The regularization Bayesian(BR) training algorithm.

6. The stage of obtaining results:

- Calculated output.
- The value of the error measure can be assigned before the network training process and this value can be decreased or increased according to the nature of the application used.

There were 12 networks generated according to the different choices and taking all possible possibilities for the requirements of building the neural network. The previous networks were implemented and thus 12 predictive time series were obtained. These series were grouped and the series with the least error was selected, depending on the MSE, MAPE, and MAE error measures.

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Table 3: Results of MSE, MAPE, and MAE error measures for predictive time series

			Layer Recurrent Network		
Training function	**Adaption learning functio**	**transfer function**	**MAPE**	**MAE**	**MAP**
LM	GD	logsig	0.435322059	23653.42485	660216995.4
		purlin	0.597446229	32570.81555	1220528244
		tansig	0.288948851	19499.54997	547668833.4
	GDM	logsig	0.525148342	28006.18101	940877612.4
		purlin	0.574577474	30575.39961	1120745107
		tansig	0.303295977	20621.44713	602323794.4
BR	GD	logsig	0.567799457	30161.39732	1097213468
		purlin	0.038489463	2950.759927	101966594.9
		tansig	0.204280178	13265.37713	283710053
	GDM	logsig	0.281987014	17676.11092	396142089
		purlin	0.498628503	27413.50874	876883153.9
		tansig	0.165886555	9941.702352	196326827.3

The table was prepared by the researcher based on the outputs of the MATLAB program Table (3) shows that the Layer Recurrent Network that used the training function TRAINBR and the purlin function has the least error. Therefore, it will be adopted in the future forecasting process. Table (4) gives the results of forecasting the production of dates using recurrent neural networks until 2026.

Table (4) shows the production of data according to the best network.

Table (4): Prediction results using Layer Recurrent Network

Production of Dates (Tons)	**Year**	**Production of Dates (Tons)**	**Year**
65963.03641	2012	90899.58694	2002
67475.55476	2013	81886.91268	2003
66505.4476	2014	44838.3902	2004
60755.95151	2015	42644.15372	2005
60397.73878	2016	43374.24436	2006
61389.40077	2017	43323.42371	2007
65118.36309	2018	45812.96734	2008
64489.63681	2019	48821.70297	2009
72004.12335	2020	56647.03382	2010
75715.63324	2021	61484.0607	2011

Table (4): Predictive values of the production of dates using Layer Recurrent Network

Production of Dates (Tons)	**Year**	**Production of Dates (Tons)**	**Year**
73109.23502	2025	69968.82015	2022
74156.03997	2026	71015.62511	2023
		72062.43006	2024

The table was prepared by the researcher based on the outputs of the MATLAB program

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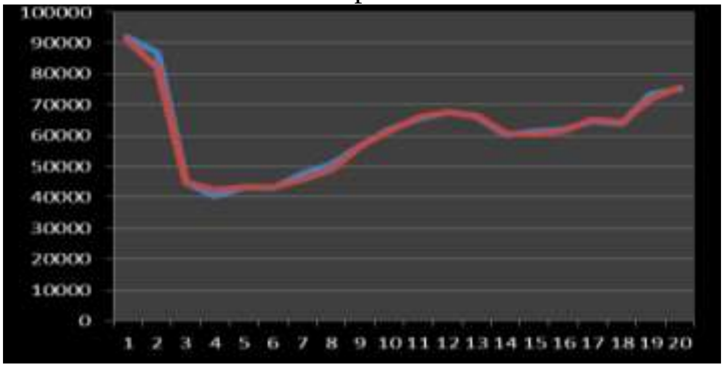
Figure 4: The original and estimated series of production dates according to Layer Recurrent Network for the period 2003-2020



4 DISCUSSION AND RECOMMENDATIONS

Through the applied study of time series analysis and using each of the Layer Recurrent Networks to forecast the production of data in Iraq, the study reached the following most important results:

1. The time series of the production of dates in Iraq has been modeled using the Layer Recurrent Network.
2. The appropriate prediction model was chosen for each of the built networks, through a comparison between the proposed models and choosing the best one based on the following criteria MSE, MAPE, and MAE error measures.
3. After selecting the best model, the Layer Recurrent Network that used the TRAINBR training function and the purlin function was adopted to predict the production of dates in Iraq.

Recommendations

1. We recommend government agencies use the models that have been reached in predicting the production of dates in Iraq during its development plans.
2. We recommend a combination of artificial neural networks and statistical methods such as ARIMA models to predict the production of dates in Iraq.

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