Using Neural Network Model to Estimate the Optimum Time for Repetitive Construction Projects in Iraq

Dr.Meervat Altaie
College of engineering/Baghdad University
Meervat3@yahoo.com

Dr.Abbas M. Borhan
College of engineering/Baghdad University
abbas_alshemosi@yahoo.com

Abstract:

The main aim of any successful repetitive construction project management systems is completing the project on accurate time, within the planned budget, and with the required quality limits Planning and scheduling. Artificial Neural Network (ANN) model used to predict the time of repetitive construction project in Iraq depends on historical collecting data adopted from (65) by using thirteen variables. The final results showed strong correlation between actual duration and predict duration there was a strong correlation equal (89.9%) between predicted and observed variables for validation data with testing error (1.51%) and training error (1.32%). It showed from ANNs model there are very good agreement with the actual measurements by found the MAPE and average accuracy percentage equal to (7.812%) and (92.18%) respectively.

Keywords: Repetitive construction projects, Predict Time, Actual Time, Artificial Neural Network, nodes, model.

Introduction:

Repetitive projects consist of a uniform repetition set of activities according to the physical layout in the project. In the project, all activities repeated from one unit to another unit and they are very important for the schedule of project which is ensured the flow without interrupted for the crew in these units. There are many unwanted consequences in delays of project that have a substantial impact on the financial returns for the interested parties especially in repetitive projects. The practical studies showed that are many Different factors causes delay in repetitive construction projects, and the causes

differ from one country to another, like the environment , work cultures, management style, construction methods ,geographical condition, stakeholders ,government policy, situation of economic , resources availability, political situation .

On the other hand, these factors are mostly identical across developing countries, but they are in different rankings according to their importance.

In Iraq, repetitive construction project needs a modern technique that has some characteristics such as

usability, accuracy, modernity, and rapidity to be used in order to overcome the delay.

In the field survey, we found out through our interviews with engineers and managers there are many factors influence the time of construction tasks and there are difficult to identify to avoid these problems. According to this reason we used the Feed- Forward Neural Network (ANN) models which have been successfully utilized in predicting time for repetitive construction projects.

The applications of ANN returne to the early 1980 , cover a very wide area in construction issues, and developed to assist the managers in many crucial construction decisions. many models were designed for cost estimation, , predicting production rate, decision making …etc. neural network has an ability to derive meaning from imprecise and complicated data ,that can be used to extract patterns and detect trends to be noticed by either computer techniques or humans.

In general, one of the most common problems in the construction project is delays. Delays is the late of completing works comparing to the planned or contract schedules, it minimized only when their cause are identified. the causes can be obtain according to number of reasons due to the client, the contractor, owner, or a third party.so without proper planning, there are many problems will occur such as exceeded the specified cost and extension of time or time overrun, so the Planning and scheduling is very important in any construction project.

Objectives

The study developed a model by using ANN which recommends scientific and practical to use the best time in project or reduce it in the planning and scheduling in repetitive projects also that can take the influencing of many principle factors in order to assist project manager.

Methodology of Research

To achieve the required objectives above, the following methodology is depended:

1. Theoretical study included reviewing international and national references, theses, and papers, relating to the research subject , and national instructions.
2. Field study included the following stages;
   a) First stage : description and identification of involved data,
   b) Second stage: developing the ANN model and discussing the results from ANN model.
   c) Third stage presented the ANN model validation.
   d) Final stage discussed the conclusions and future works.

1- Theoretical study

- **Literature review**

In the table (1), there are the brief descriptions of studies and researches in the repetitive construction projects that are related to the planning and scheduling.

Table .1 brief descriptions of studies

No.	author	year	tools	description
1	El-Rayes	2009	genetic algorithm approach	developed a model to optimize the planning and scheduling of repetitive construction projects to minimize the cost and duration
2	Hyari	2012	A Multi-objective Model	The model used to optimize resource utilization in repetitive infrastructure projects in order to provide the capability of both project duration and work interruptions for construction crews
3	El-Kholy	2012	a multi-objective fuzzy linear programming model (FLP)	to generate and evaluate the optimal trade-off solution between any two objectives that suit his demands
4	Eid	2012	Apply Genetic Algorithms technique	to determine the set of optimum solution through optimizing the solution to achieve the multi-objective criteria needed by planners
5	J.Jorge Ochoa	2013	develop a method for scheduling repetitive projects	This method with objectives would help to minimize project duration, project cost and both of them with constraints of precedence relationships between activities.
6	Yi Su	2016	the Linear Scheduling Method (LSM) and Line-of-Balance (LOB)	to analyze repetitive work and approved a plane to arrange the productivity, number, and size of crews and their lead or lag.
7	Jeeno Mathew	2016	developed a method with objectives	to minimize project duration, project cost and both of them with constraints of precedence relationships between activities
8	Noor Abdulsttar	2018	Using nonlinear regression and genetic algorithm method	Developed a mathematical model to predict the time of repetitive construction projects as well as to choose the best model

- **ANN applications in construction management**

In construction management, numbers of researchers have applied ANN approach in their researches. The following are the brief descriptions of studies and researches used ANN approach in decision making, forecasting, and optimization:

1) Chua et al. (1997) identify the main management factors that are very important in affecting budget performance in the project.(8)
2) Adeli and Wu (1998) , study the cost of reinforced concrete pavement and developed a regularization neural network to estimate the real cost of reinforced concrete.(2)

3) Hegazy and Ayed (1998) developed a model for highway projects and used the ANN approach in order to develop a parametric cost-estimating for highway projects.(10)
4) Morcous , et al (2001) Using Neural Networks in preliminary quantity estimate of highway bridges in Egypt .(14)
5) Al-Zwainy (2008) in Iraq, estimate the total cost of highway projects by developed four models of the ANN. (5)
6) Pewdum (2009) forecasted the final budget and duration of a highway in construction project by developed models of ANN approach during construction stage. (19)
7) Attal (2010) based by the development of ANN model to prediction the construction cost and duration in highway projects. (7)
8) ElSawy (2011) used ANN approach to develop a parametric cost-estimating model for site overhead cost in Egypt. (10)
9) Petruseva (2012) developed ANN model for Predication the duration of construction project. (18)
10) Al-Zwainy (2012) study the productivity estimation works of stone tiles in building project and depended on back propagation Feed-forward to estimate the finishing works. (6)
11) Pesko (2013) developed a model for urban road construction by used ANN approach in preliminary estimate of time and cost for these projects. (17)
12) Naik and Radhika (2015) used ANN model in analysis of time and cost in highway and road construction project. (15)
13) Aljumaily (2016) improved a mathematical model using ANN for predicating the duration of irrigation channels projects in Iraq. (3)
14) Vahdani (2016) presented a prediction model based on a new neuro-fuzzy algorithm for estimating time in construction projects in the construction industry in Iran. (20)
15) Al-saadi (2017) used ANN model to estimate the duration of road projects in Iraq using six variables (length of road, No.of lane, No.of intersection, volume of earth, type of pavement and furniture level). (4)

The gap in these previous studies, the researchers are not concerned with predicting time for repetitive construction projects.

2- Field work

•Factors affecting to predict time for repetitive construction projects

The evaluation and identification the factors that affect the predicting time for repetitive construction projects is a critical issue facing the engineering

estimator. Understanding the critical factors that affect the estimation of the duration, whether positive or negative, can contribute to the development of a strategy to reduce the shortcomings and improve the effectiveness of the performance of the construction project.

Historical data was collected from completed repetitive construction projects in Iraq. The researcher succeeded in gathering well trusted data about (65) projects from previous experiment study belongs to abdul-jabbar thesis (16). She created a mathematical model to predict the time of repetitive construction projects using nonlinear regression and genetic algorithm method .Table (1), show the summary of historical data. The sample has been directed to 16 experts in this field. They asked to pinpoint the foremost important factors influencing in predicating time.

Table .1 Descriptive for Important factors influencing in predicating time

NO	Factor	Weight	Range	RII%
F1	Administrative factors affect the success of the project	4.6	V. agree	92
F2	Political factors and Government instructions effect on the project success	4.5	Agree	89.8
F3	Operational factors affect the success of the project	4.3	Agree	85.4
F4	The Planning Department seeks to develop and modernize the planning process and measure their success	4.04	Agree	80.8
F5	The extent to which modern documentation system to gather information and data on other projects and implemented.	4.04	Agree	80.8
F6	Provide a modern information management system data are updated continuously.	4.02	Agree	80.4
F7	Provide information management system allows easy communication between different administrative levels for the project	4.00	Agree	80.0
F8	Provide technical and administrative measures for effective control over the planning and execution of the work	4.16	Agree	83.2
F9	The possibility of material incentives for workers in management and planning	4.20	Agree	84.0
F10	Engaging activities for employees to quality and continuous improvement processes	4.5	Agree	90.0
F11	Involvement of employees in training courses and programmers for planning and programming.	4.35	Agree	87.0
F12	The Department's ability to provide detailed plans and Start by preparing a detailed project plan and work programs include project termination deadline	4.38	Agree	87.6
F13	Raise the level of workers	3.96	Agree	79.2

- Mathematical model of ANN

The integrated scientific methodology used to build the ANN model to predicate time of repetitive construction projects. Including the following steps:

1) **Selection software** :

In our research we used NEUFRAME V.4 , as the most common program for researchers .It is an integrated group of intelligence technology tools that include Neural Networks logic, the purpose is determining the relationship between the independent (input)

variables and dependent (output) variables. Fig (1) illustrates its architectural layout of NEUFRAME V.4.

2) Input information Data(actual data)

In order to reducing the speed of the learning process in the neural network, we must increase the number of variables (input and output) to improve the size and the efficiency of the ANN model. We select the Method of Prior Knowledge in our research, which is widely used in the construction sector that is approved in many researches when there is no prior knowledge of the input variables and their effect on the output variables.

The research model consist from thirteen variables as an input data to predicting the reliable time for repetitive construction projects as an output variable .

Fig. (2) Illustrate the inputs and outputs in the NEUFRAME program.

3) Data Division

The actual data is divided into three main groups s mention below. It is a critical and very important step the neural network.

1) Training group: build the neural network model, and adjust the weights connected to the neural network.
2) Testing group: test and check the network performance at different stages of education. When the error of testing or examination group increases the training stage is stopped.
3) Validation group: estimate the performance of the model in the applicable environment, and assess the performance of the model once the neuronal network training has been successfully completed.

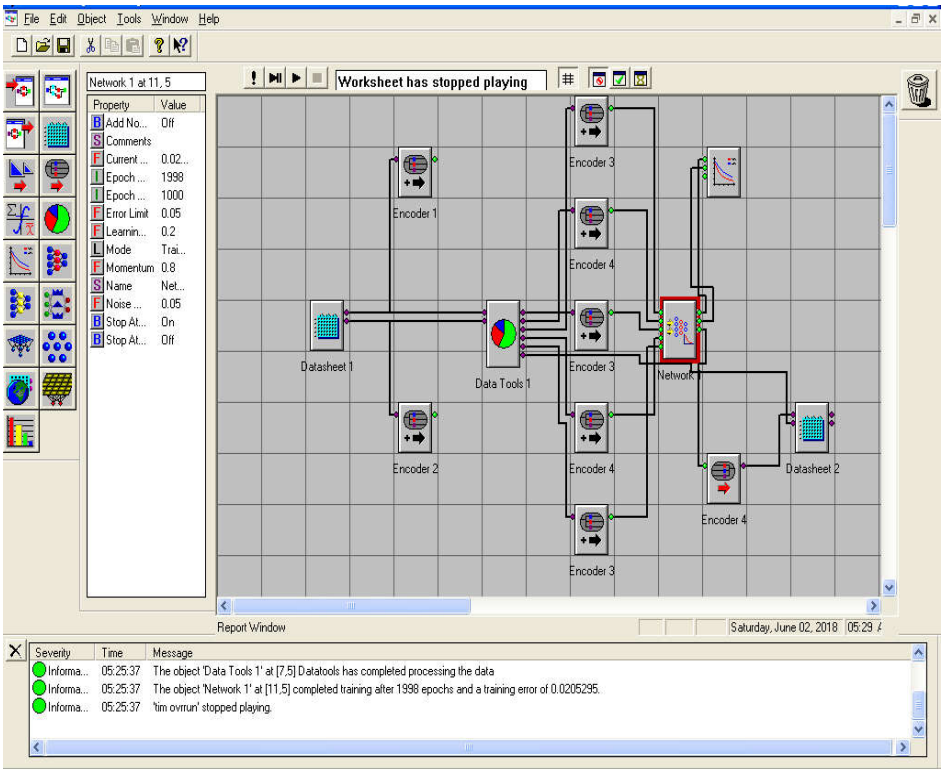

Fig .1 Architectural layout of NEUFRAME V.4.

Fig. (3) Show the percentage of data breakdown for the training, testing and validation groups using the trial and error method. We used different percentages of data as an attempt to obtain the best performance of the neural network in order to reach the highest correlation coefficient and showing the strength of the relationship between the output of the neural network and measured output with conjunction the lowest error rate for the testing group. The final criteria are adopted to choose the best division of data in order to obtain the best performance of the neural model.

The best division of data is 72.31% for the training group, 12.31% for the testing group and 15.38% for the validation group, with the lowest error rate of the test as shown in Fig. (4).To distribute the actual data, the NeuframeV.4.program provides an efficient way in three ways:

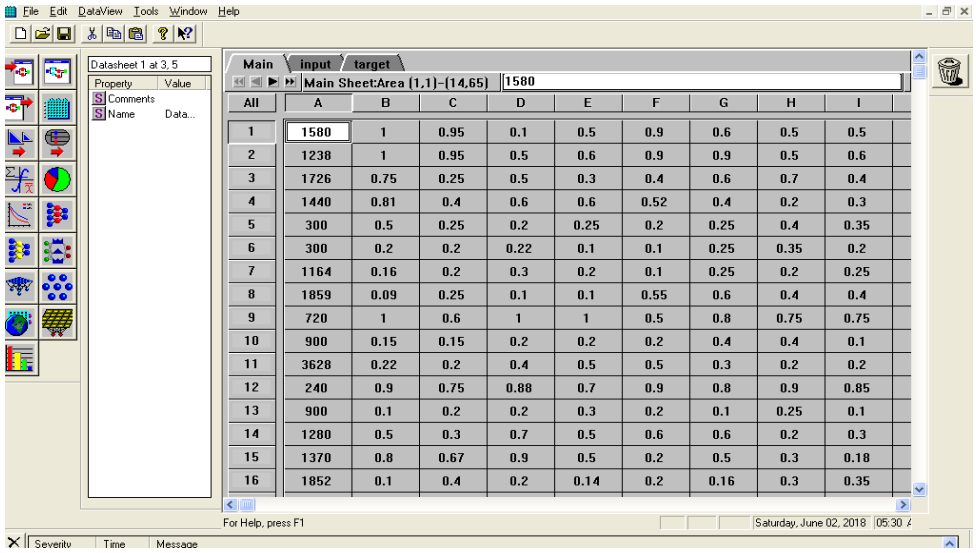

Fig. .2 Inputs and Outputs in the NEUFRAME V.4. Program.

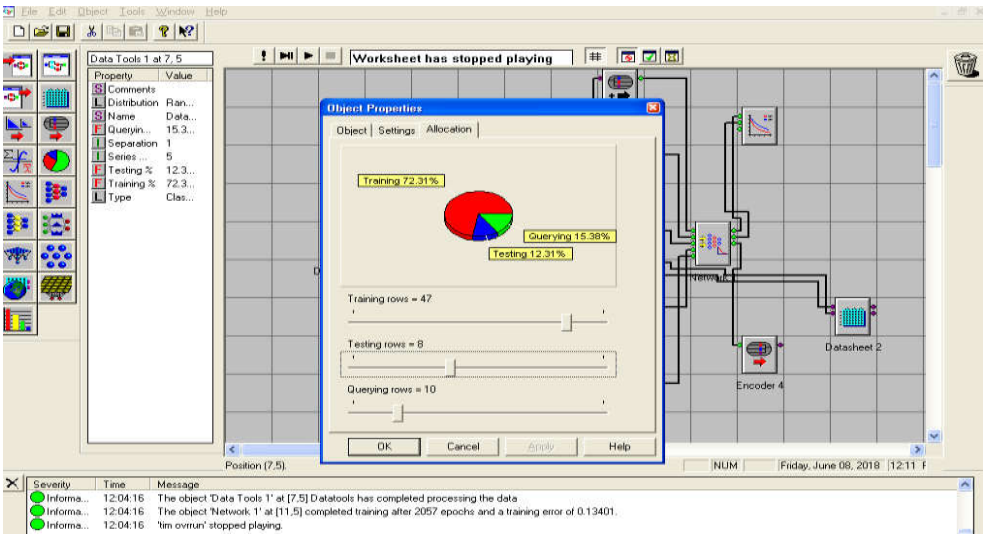

Fig. 3Percentage of Data Breakdown (Training, Testing, Validation)

1) Random mode method: the program randomly distributes variables data on the three groups and according to the percentages obtained.

2) Strip mode method: the program divides the total data into non-specific sets of packets, and each package includes data for the training group, the testing group and the validation group,

3) Blocked mode method: the total data is treated as one packet and divided by the three groups.

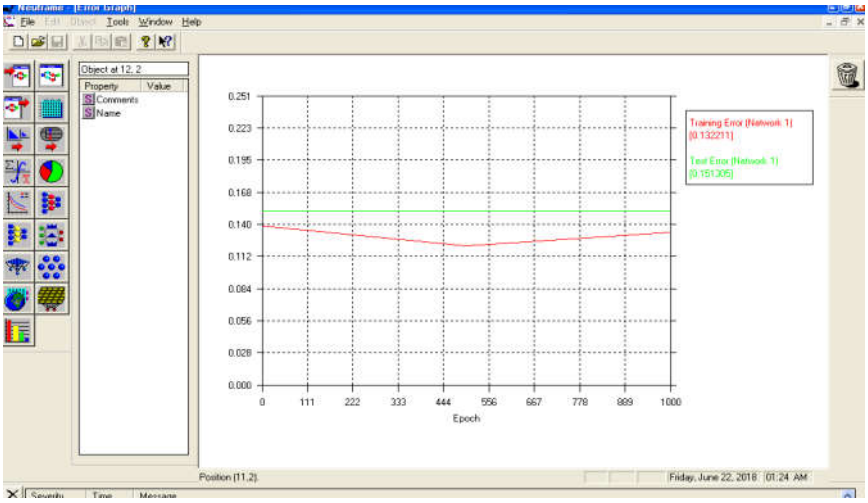

Fig.4Training Error and Testing Error

Fig.(5) Illustrate the effect of the use in different options (random, blocked, strip) it can be observed that the best performance of the neural network is when we using the blocked division method, because it has the least error for the test.

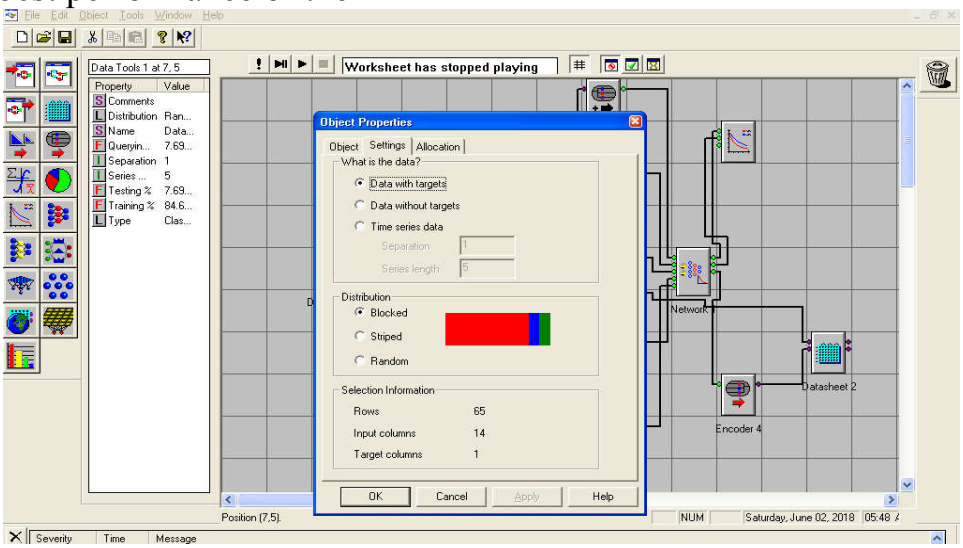

Fig.5options for data divisions

4) Architecture of the Neural Network

The success of the Neural Network is depending on the determination of the appropriate number of Neural nodes in the hidden layer, it is an important factor The number of nodes in the input layer is equal to the number of factors affecting to predict the time of repetitive projects. The output consists of one neuron can be measured the prediction time.we used the default parameters in the Neuframe program like (Learning Rate =0.2 ,Momentum Term values =0.8 and the Transfer Function in the output layer and the hidden layer is Sigmoid).so the typical form of this developed network is a three-layer

neuron, consist from an input layer includes 13 neurons, hidden layer which is comprising three hidden nodes and output layer only one neuron .

Fig.(6) Explained the appropriate number of neural nodes, and Fig.(7) Showed the option of Neural Network Architecture.

5) Adjust the weights and extract the mathematical equation

The connection weights (The small number) obtained by Neuframe for the optimal model cab be translated into relatively simple formula to enables the network. Table (2) showed the connection weights and the bais (threshold levels) and summarized to demonstrate this.

Before using Equation (1) all input variables which are using as the data ranges in the ANN model training should be normalize and scaled between 0.0 and 1.0, by using the following Eq.(2) :

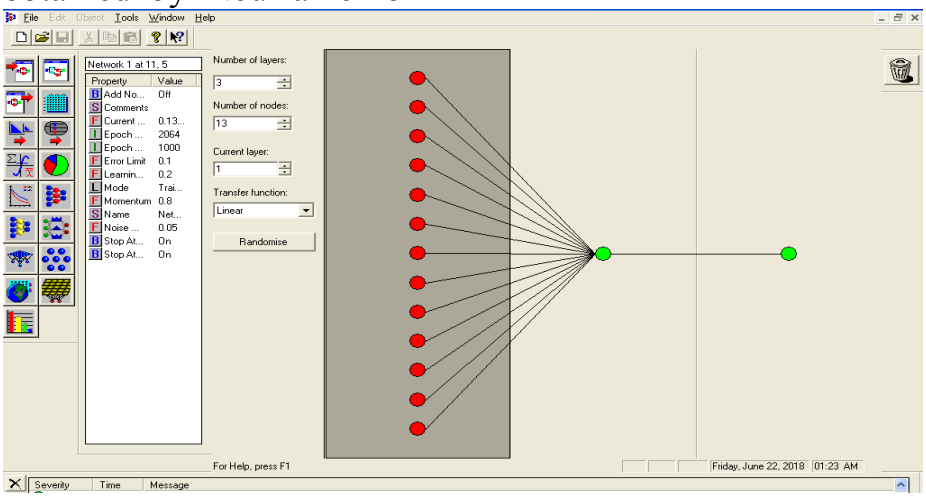

Fig.6 Neural Network Architecture

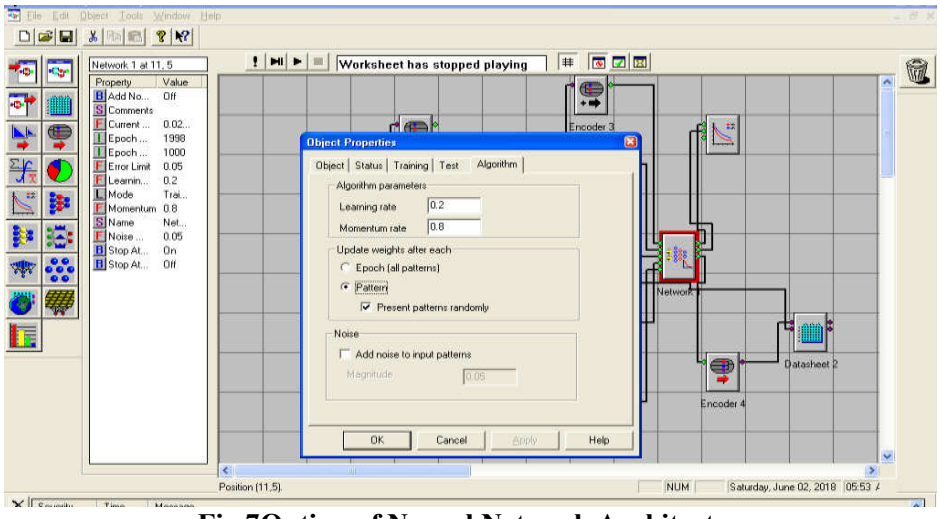

Fig.7Option of Neural Network Architectur

Table .2 Weights detail from Node between Input Layer and Hidden Layer

Hidden layers Nodes (i)	Wji (weight from nodes (i) in the input layer to nodes (j) in the hidden layer							Hidden layers threshold θj
i=14	i=1	i=2	i=3	i=4	i=5	i=6	i=7	0.4597618
	0.083756	0.33304178	0.3748374	-0.0671104	-0.254562	-0.064911	0.658355	
	i=8	i=9	i=10	i=11	i=12	i=13		
	0.3342788	-0.3039118	-0.321864	0.1346746	0.4907970	-0.068485		
Output layer nodes	**Wji (weight from node i in the hidden layer to node j in the output layer)**							**Output layer threshold θj**
	i=14							
i=15	-0.4313679							-0.3992751

$$X = 0.4597618 + 0.083756\,X1 + 0.33304178\,X2 + 0.3748374\,X3 - 0.0671104\,X4 - 0.254562\,X5 - 0.064911\,X6 + 0.658355\,X7 + 0.3342788\,X8 - 0.3039118\,X9 - 0.321864\,X10 + 0.1346746\,X11 + 0.4907970\,X12 - 0.068485\,X13 \quad \ldots\ldots\ldots (1)$$

$$x_n = \frac{x - x_{min}}{x_{max} - x_{min}} \quad \ldots\ldots\ldots (2)$$

where
x = input variable
x_n = scaled value of input variable (x).
x_{max} = maximum value of input variable
x_{min} = minimum value of input variable

In our research study ,all input variables which are obtained in the survey study were scaled between (0.0 and 1.0).
The prediction of the equation can be expressed in the following equation:

$$y = \frac{average\ y}{1 + e\ (\text{Buis} + w \tanh X)} + \text{minimum y} \quad \ldots\ldots (3)$$

the predicated time value should be also scaled between (0.0 and 1.0) in order to calculate the actual value of time . TPT represented the total predicting time in days for any repetitive construction project, as mention below in the following equation:

$$TPT = \frac{1786}{1 + e\ (-0.3992751 - (-0.4313679 \tanh X)} + 680 \quad \ldots\ldots (4)$$

6) Validity of the ANN Model

Fig.(8)Showed the final predicted and actual (observed) values of output in ANN model.

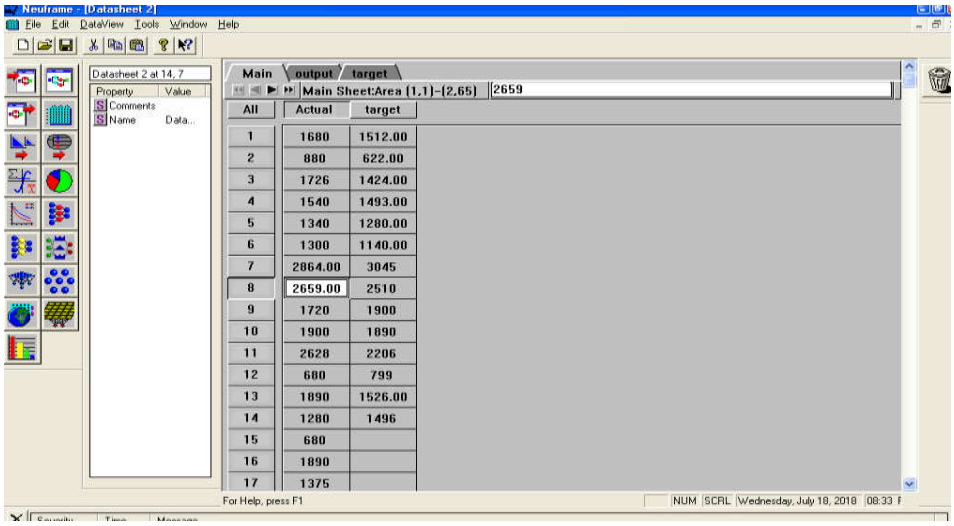

Fig.8Actual time and Predicted time

Statistical analysis are used to measure the performance of the ANN Model included the following approaches:

1- Mean Absolute Percentage Error (MAPE) ,it is a measure of prediction accuracy of a forecast ting method in statistics

$$MAPE = \frac{100\%}{n} + \sum_{n=1}^{n} \left| \frac{At-Et}{At} \right| \text{ ..... .(5)}$$

Where

A_t = the actual value

E_t = the estimated value

n = the numbers of cases (14 for validation)

2- Percentage of the Average Accuracy (AA %) , Where:

AA % = 100 % - MAPE …… (6)

3- The Coefficient of determina-tion (R^2)

4- The Coefficient of correlation (R)

Table(4) in the following below showed the validation results of the ANN model using statistical methods .the percentages of MAPE and AA% generated by ANN model were found equal to (7.812%) and (92.188%) respectively . it is clear that the ANN model show very good agreement with the actual measurements.

Table .4 the comparative study of results of the Neural Network Model

Description	ANN validation
MAPE %	7.812%
AA%	92.188%
R	94.8%
R^2	89.8 %

Fig.(9) assessed the predicted values of time are plotted against the measured (actual) values of duration for validation data set. the capability of ANN model uses the validation data set. Coefficient of determination (R^2) equal to (89.9 %), therefore it can be concluded that ANNs model show a very good agreement with actual duration.

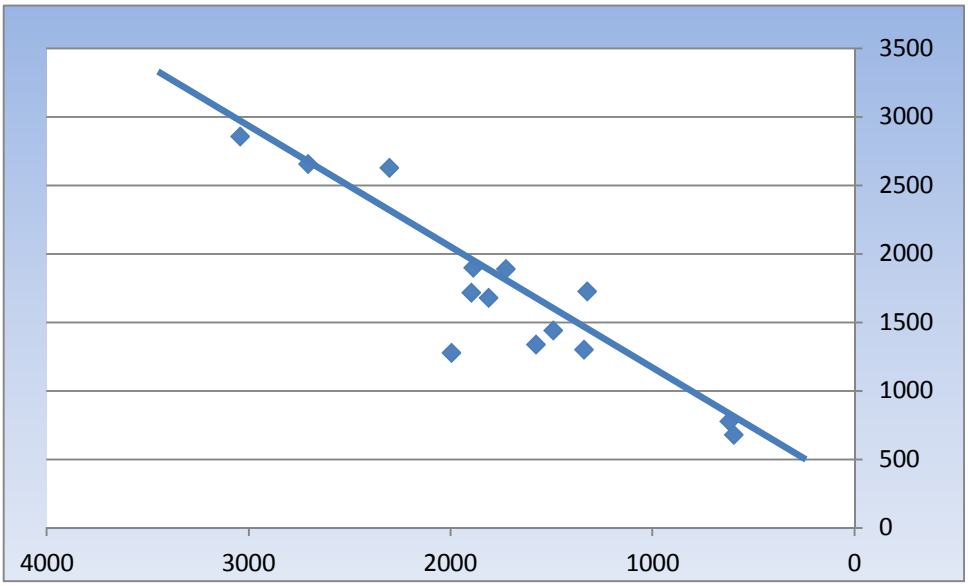

Fig.9. Comparison of Predicted and Observed Duration for Validation

Conclusion

The main aim of this study is to use Artificial Neural Networks Model which recommends scientific and practical to predicting the optimum duration to complete the repetitive construction projects in Iraq in the planning and scheduling stages that can take the influencing of many principle factors in order to assist project manager.

It was very necessary to ensure the success of project management depending on the application of artificial neural networks as a new method in the project management. It was found that these networks have an excellent predictability of 78.2% as average of accuracy and correlation coefficients (91.8%).

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استخدام الشبكة العصبونية (ANN) لتخمين الوقت الامثل للمشاريع الانشائية التكرارية في العراق

م. د. ميرفت رزاق الطائي
كلية الهندسة/ جامعة بغداد
Meervat3@yahoo.com

م.د. عباس محمد برهان
كلية الهندسة/ جامعة بغداد
abbas_alshemosi@yahoo.com

الخلاصة :

الهدف الاساسي لنجاح ادارة المشاريع للانظمة الانشائية التكرارية هو اكمال المشروع في الوقت المحدد ضمن الميزانية المخططة له وضمن الجودة المحددة في مراحل التخطيط والبرمجة. تم استخدام تقنية الشبكة العصبونية (ANN) للتنبؤ بالوقت اللازم لاكمال المشاريع الانشائية التكرارية في العراق بالاعتماد على بيانات خاصة لـ(65) مشروع انشائي باستخدام ثلاثة عشر متغير .النتائج النهائية اثبتت وجود علاقة قوية بين الوقت الحقيقي والوقت المخمن حيث كان معامل الارتباط قوي والذي بلغت قيمته(89.9%) بين المتغيرات المخمنة والمتوقعة للبيانات بوجود خطأ مقداره(1.51%) في مرحلة الاختبار وخطأ اخريبلغ (1.32%) في مرحلة التدريب . وهذا يظهر ان النموذج المستخدم تقنية الشبكة العصبونية اعطى موافقة جيدة على القياسات الواقعية من خلال ايجاد مقدار خطأ النسبة المطلقة للمتوسط ونسبة معدل الدقة (7.812%) و(92.18%) على التوالي.

الكلمات المفتاحية: مشاريع الانشاء التكرارية , وقت المشروع، الوقت الحقيقي، الشيكة العصبونية،عقدة،موديل.