A time series based prediction model for urban development plans using an Artificial Neural Network: Koya in 2020

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Abstract

Urban development plans always designed based on two important factors; population growth and city's expansion. In many cases, the size of expansion of a city depends on the rate of population growth. The expansion process for a city may include many types of projects, such as building new residential and commercial areas, opening internal and access roads, constructing new service buildings (schools, hospitals, etc.) with providing many types of services such as electricity power, communication access points and towers, and sewerage with water net systems. In this project, an accurate prediction model with prediction function is proposed. The model depends on a time series based Artificial Neural Network to achieve the work. The input data for this model will be the number of families, number of students, and number of registered cars to get fuel in Koya petrol stations. These records that are distributed over different spans of years (from 2000 to 2013) were collected in Koya city. This work has general and specific aims. The specific aim of this work is to support some governmental service departments in Koya through providing a correct prediction about the size of requirements for this city in 2020. This case could be generalized to other cities similar to Koya, which is the general aim of this work.

1 Introduction

Due to improving the income of people in Koya city, the expansion of this city has been growing rapidly since 2003. There are many new quarters and residential areas have been settled, many new access and internal roads have been constructed, and many schools and hospitals have been built. Moreover, the area witnessed establishing a new university (Koya University). This

expansion started immediately after 2003, when Iraq in general and Kurdistan Region more specifically have been liberated from a strong control of a peremptory regime. Such expansions should be achieved with a very strong plans and preparations, however, there wasn't any plan for cities and there were no drawings and designs for the city's future. Moreover, there was nothing called master plan for this area. This situation wasn't only covered Koya city; however, it covered all Iraq's cities. The mentioned expansion was processed without any plan, and many mistakes followed the achievement process. Therefore, this work proposes a prediction model to obtain some figures about this area, and based on, correct plans can be designed.

This work proposes an Artificial Neural Network (ANN), as a prediction model [1], to simulate the past data of Koya city and predict some figures about the future expansion of this area. This work depended on Time Series data; therefore it employed the time series ANN. Such structure of ANN has been employed many times as forecasting models for climate prediction, economic estimation, disease analysis, and energy consumption computing [2, 3]. Data for this work has been collected in three different areas; family numbers, student numbers, and number of cars that their owners are live in Koya. Simulation on each datasets has been done individually. Each simulation gives a specific regression equation, and this work tested them individually. Results showed that the average performance of this model is 0.0635. The average growth in this city is 65.11%.

2 Urban development prediction model

2.1 Data collection

To check the way that a city might be expanded, figures from different fields can be analyzed. A dataset from education, number of houses, number of families, number of vehicles, and number of patients can be used to answer how a city is expanding? In this work three types of dataset are involved; number of students, the number of families and the number of cars that stayed inside Koya for 24 hours, seven days a week. Because the prediction model of this work is the time depended model, the timeline of collected data is also considered. Table 1 shows figures of data collected from three different fields.

2.2 Time series based ANN

In this work, there is a time series type of problem. Therefore, the type of Neural Network (NN) that proposed by this work is a time series based NN. Figure 1 shows the structure of the proposed network, and the output prediction of this model is shown in equation (1) [4]. This work uses Matlab simulation to build the proposed prediction model [5].

$$y(t) = f(y(t-1), \dots, y(t-x), i(t-1), \dots, i(t-x)) \quad (1)$$

where $y(t)$ is the output at time t , $i(t)$ is the target at t , x is the size that set feedback delay size.

Table 1: Records used as input for the time series based Neural Network.

Year	No. of students	No. of families	No. of cars
2000	12743	9553	691
2001	13630	10471	705
2002	13980	10853	753
2003	14020	11560	1134
2004	14178	11889	1328
2005	14638	12204	1324
2006	14994	13074	1449
2007	15169	14077	1599
2008	15543	15367	1682
2009	16050	15945	1752
20010	16620	16501	1818
2011	16813	17032	1905
2012	17162	17725	2005
2013	17566	18529	2106
Collected from:	General Directorate of Education in Koya	Center of food distribution in Koya	Center of fuel coupon distribution in Koya

Figure 1: The structure of a time series based neural network.

2.3 Training phase

To teach the proposed model, this work has clamped each dataset to ANN individually. At each training cycle, the proposed ANN will learn how the way of expansion of an event (number of families increasing, student's number increasing, and the car's number increasing) is going on. Figures 2 below show the training performance of each dataset individually.

Figure 2: Training phases of proposed ANN on three dataset types.
 (a) Training on family numbers; (b) Training on student numbers;
 (c) Training on car numbers.

2.4 Testing phase

To test the ANN model, this work has partitioned each dataset into two groups; the first group is used for training phase, which covers 75% of the whole data. The second group, which covers 25% of whole data, is used for testing. Data in the second group has not involved within the training phase. Therefore, they can be considered as unseen data. The performance indicator has been computed for each testing phase. The calculation of performance indicator depends on Equation (2) [6].

$$Output = \frac{1}{n} \sum_{i=1}^n (\hat{y}_i - y_i)^2 \quad (2)$$

where $\hat{y}$ is the predicted value and y is actual value at time i . Table 2 shows the performance indicator for each testing phase.

Table 2: Performance indicators for time based Neural Network prediction model.

Performance indicator	Family numbers	Student numbers	Car numbers
Mean squared normalized error performance function	0.0146	0.0812	0.0947

3 Predicted rate for events

As indicated in Table 1, the performance indicator for the ANN model is good enough for making prediction for each event that mentioned in section 2.3. The input value for each training phase is 2020, which is the time when this work attempted to find the prediction rate for three events. Table 3 shows these rates.

Table 3: The prediction figures for 2020.

Year	Predicted number of families in Koya	Predicted number of students in Koya	Predicted number of cars at Koya
2000	10441	12743	690
2010	16994	16610	1754
(Predicted) 2020	25682	20978	2913

4 Conclusions

To cover city's expansion, it is very necessary to estimate how the population is growing. Accordingly, many population dependent parameters can be analyzed then estimation can be obtained for a few years in advance. This study showed some figures about Koya city through three different parameters. The first parameter is family number, which has been estimated that average increase for every 10 years is 56.9%. The second parameter is student number. The average

increase is 28.45%, while the average increase of car's number for every ten years is 110%. From these three figures we can conclude the following points:

1. The number of family members is more than four, because the percentage of increasing the family numbers is passed 50%. This point can be bring the attention of Koya municipality, Koya Center for Food Distribution, Power Distribution Department in Koya, Post Office and Communication Department in Koya, and Health Care with Hospitals in Koya.
2. Growth of student's number is changed very stably. An education department in Koya can proceed with their plan, if they have, to keep their capability of registering new students. They should keep in their mind that every year around 700 new students are expected for registration.
3. Private transportation becomes more popular that public one. This pushes Traffic Department in Koya to work harder to provide parking, traffic jam arrangement, and more licenses are expected.

References

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