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Traffic Flow Forecasting in Leisure Farm Areas Using Artificial Neural Networks

***Abstract**. Leisure agriculture experiences continuous development. However, because most leisure farm areas are located in isolated or remote regions and the planning and construction of traffic networks is greatly restricted by terrain and geographical features, the roads in these areas are narrower than those in other regions. This study focuses on traffic flow forecasting using the advanced artificial intelligence technology of artificial neural networks (ANNs) and makes a positive contribution to the forecasting methods for traffic flow regarding leisure farm areas.*

***Streszczenie.** W artykule przedstawiono zaawansowany sposób prognozowania ruchu ulicznego w rejonach ośrodków wypoczynkowych, oparty na budowie sieci neuronowych (ANN). Opracowana metoda, zwiększa stan wiedzy na temat przewidywania płynności ruchu ulicznego w tych rejonach. (**Prognozowanie płynności ruchu ulicznego w rejonach ośrodków wypoczynkowych, z zastosowaniem sztucznych sieci neuronowych**).*

Keywords: Traffic flow, artificial neural network (ANN), leisure farm areas, artificial intelligence.
Słowa kluczowe: Słowa kluczowe: płynność ruchu ulicznego, sztuczne sieci neuronowe, rejony wypoczynkowe, sztuczna inteligencja.

Introduction

Leisure agriculture experiences continuous development. However, because most leisure farm areas are located in isolated or remote regions [1] and the planning and construction of traffic networks is greatly restricted by terrain and geographical features, the roads in these areas are narrower than those in other regions. Consequently, transportation planning and diversion for leisure farm areas have become the priority for travel planning, in which the precise forecast of traffic flow constitutes the essential basis. Therefore, traffic flow forecasting for leisure farm areas is gaining importance. This study uses the traffic flow of the Old Mountain Line Leisure Farm Area in Sanyi Township, Miaoli County as an example.

Depending on the time of the forecasts, traffic flow forecasting consists of long-term[2][3] and short-term[4] forecasts. Problems in traffic flow forecasting result from the temporality, complexity, and uncertainty in road traffic systems. Specifically, short-term traffic flow forecasts are more greatly impacted by random interference factors, experience higher uncertainty, and show less obvious patterns or regularity. This is the main reason short-term traffic flow forecasts are more difficult than middle- or long-term forecasts.

Especially for leisure farm areas, which are relatively remote, novel methods for forecasting traffic flow are required because traditional forecasting techniques cannot provide ever-increasing requirements for precision in real life and typical pure mathematics methods cannot produce satisfying forecasting results. With the development of modern computer technology, new techniques and methods, such as fuzzy logic, grey prediction, and artificial neural networks (ANNs), have been proposed [5]. ANNs have been widely used in information forecasting field.

This study incorporates ANN techniques into the forecasts for traffic flows in leisure farm areas. By performing useful modifications and tests for the forecasting method of traffic flow for leisure farm areas, this study improves the ease of travel planning.

Artificial Neural Networks

ANNs represent a branch of science that imitates biological neural networks with the help of computers. The network can acquire accumulated experience from past environmental data, transforming this into knowledge and storing it. Furthermore, stored knowledge can be used to construct intelligent algorithmic programs or processes for subsequent forecasts or identification. ANNs are one of the most important branches of artificial intelligence [6][7].

An ANN could be understood as an abstract version of a biological neural network, the most advanced of which is the human brain. The structure of a neuron is shown in Fig.1. As a type of experiential model, an ANN imitates several basic elements in biological neural networks using computer systems [8]. It is a nonlinear dynamic system consisting of massive artificial neurons that have ample and complete links.

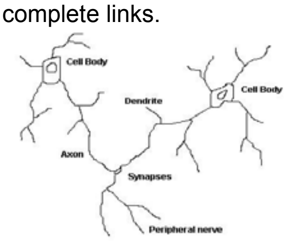

Fig.1. Structure of a neuron

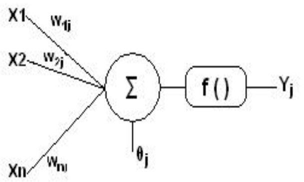

Fig.2. An artificial neuron

From a mathematics perspective, these neurons display a highly abstracted and simplified structural model of neurons or cells in the human brain. Fig.2 shows a model of a typical artificial neuron. A neural network is established when several neurons are connected organically in a particular manner of connection. Fig.3 shows a schematic of an ANN in which every neuron is capable of accepting multiple input signals, which are converted to output signals according to a particular rule.

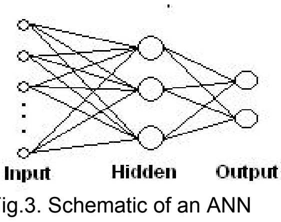

Fig.3. Schematic of an ANN

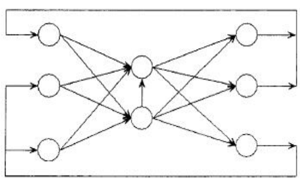

Fig.4. ANN network structure

Fig..4 shows a feedforward network structure with feedback functionality that provides information feedback from the output layer to the input layer. Similar structures include neurocognition and backpropagation neural networks, which perform well for storing particular model sequences [9][10].

Methodology

So-called transportation forecasting, which is designed to improve road service, consists of the evaluation of the influence of construction work on traffic and the effectiveness of the construction of road networks for traffic. The use of ANNs in the forecasting field began in the 1980s. Compared with traditional forecasting methods, ANNs have numerous enhancements and advantages, including that they help monitor production processes, determine causal relationships, improve precision compared to general statistical methods, and reduce calculation complexity and volume as compared to general statistical methods. There are three major steps in forecasting traffic flow using a backpropagation neural network. The first step is the preparation and initialization of training samples. The second is the training of an ANN. Third, the forecasts regarding traffic flow are made using the trained ANN. The learning flow chart of this type of traffic flow forecasting model is shown in Fig.5.

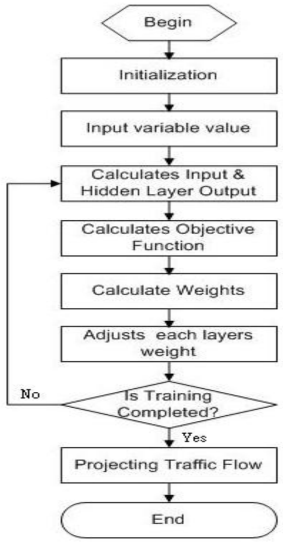

Fig.5. Learning flow chart of a traffic flow forecasting model

The traffic flows in each road section in the network, especially in the adjacent sections, were correlated to a certain level and the daily traffic flow for each road section was statistically normal or standardized regarding time distribution. From the perspective of time, the distribution regularity in the daily peak and off-peak times appeared to be robust to a certain degree, and the road sections typically had two peaks, an early peak and late peak, and could be observed daily in the road sections. From the perspective of space, the traffic flow in the road section was unquestionably and necessarily correlated with the traffic flow in the previous periods in the same road section, and the traffic conditions of the road section were necessarily affected by those of the upstream and downstream sections. Accordingly, we can forecast the traffic flow of a specific road section using the traffic data from previous periods and the upstream and downstream sections.

We designed a neural network forecasting model according to the mentioned features and the distribution of the input data. The model examined the regularity in the time change of the traffic flow at the checkpoint, and the input data was derived from multiple checkpoints for road sections. To forecast the traffic flow, we used the data acquired from the forecasting checkpoint and its adjacent checkpoints as the input variables.

Fig.6 shows a schematic of the structure of a road junction, in which represent the traffic flows from the north, south, east, and west and all of the inlets or entries at time t in the upstream sections. In addition, is the traffic flow leaving from the east or at the east exit at time t, and V(t) is the traffic flow entering the downstream sections at time t (t = t + △t).

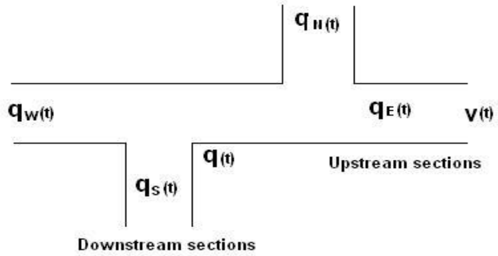

Fig.6. Schematic of the road junction structure

To forecast the traffic flow, we used the traffic flow v (t – a △t) (a = 0, 1, 2, ⋯) from the previous periods in the targeted section as the input of the ANN. The output was the traffic flow V(t) that we wanted to forecast for the downstream sections.

Data Analysis and Model Simulation

In this study, a three-layer neural network that had one input layer, one hidden layer, and one output layer was employed as the basis of analysis; this was also the optimal network structure. The input layer had eight neurons, the hidden layer had eight, and the output layer had one.

Regarding the parameters for constructing the ANN in this study, we established the expected error target as 0.002, the maximum training times as 20,000, and the initial learning rate as 0.01.

This study utilized NeuNet Pro software to perform the ANN calculation. We used 100 sets of training data, and an additional 21 sets were used for testing. The execution process is shown in Fig.7 to Fig.11.

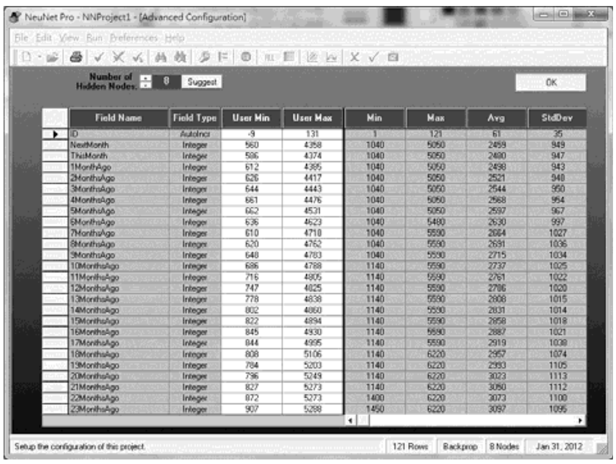

Fig.7. Data analysis

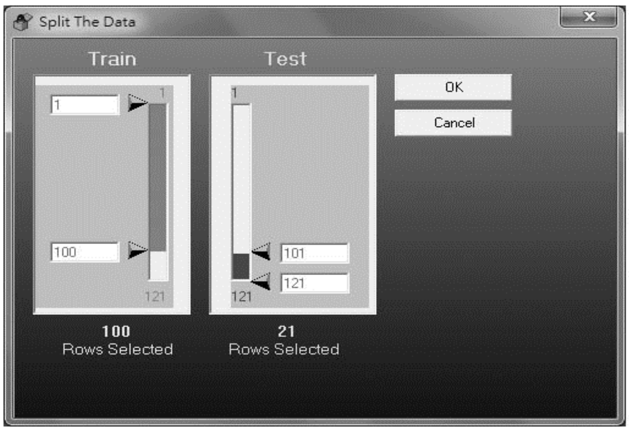

Fig.8. Training set and testing set

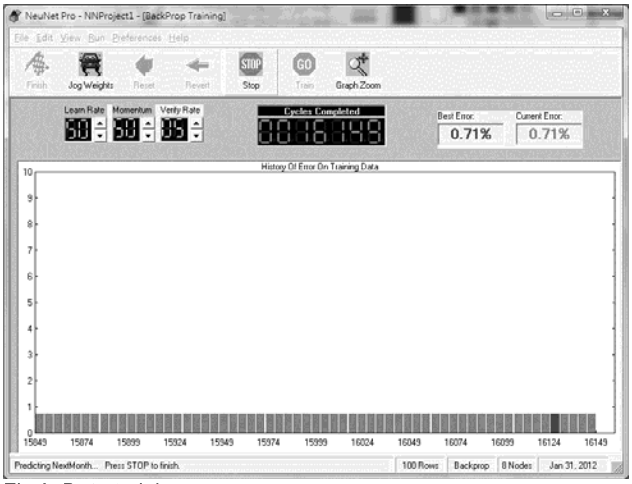

Fig.9. Data training

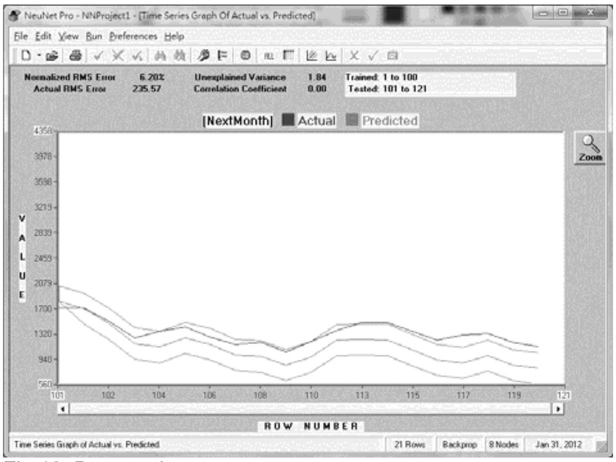

Fig.10. Data testing

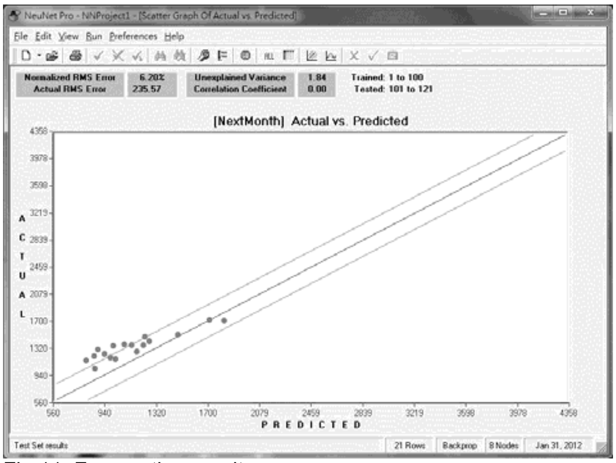

Fig.11. Forecasting result

The forecasting results produced by the training and testing of the ANN model were as follows: The normalized root mean square error was 6.20%. The actual root mean square error was 235.57. The unexplained variance was 1.84. The correlation coefficient was 0.00.

Conclusion

The ever-increasing number of motor vehicles in Taiwan has led to severe traffic issues, causing people to increasingly depend on and display more demands for traffic management. Reasonable transportation planning is an effective means for resolving traffic congestion, particularly for remote leisure farm areas, and effective traffic diversion is the focal point of travel planning. However, this cannot all be achieved without the precise forecasting of traffic flows in specific areas. Consequently, this study conducted research on the forecasting of traffic flows, especially regarding leisure farm areas. On the basis of conventional forecasting methods, we used the newly emerging ANN technique to perform relevant forecasts. The major results of our study are as follows.

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