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Normalization Methods on Backpropagation for the Estimation of Drivers' Route Choice

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Abstract

The artificial neural network has recently been applied in many areas including transport engineering and planning. Even though its successful application for wide transportation areas, there are some major issues to be considered before using the neural network models, such as the network topology, learning parameter, and normalization methods for the input vectors. In this research, several normalization methods for input vectors were studied and the experimental results showed that the performance of the drier's route choice model using the neural networks was dependent on the normalization methods. For the estimation of driver's route choice, the best normalization method in the Backpropagation neural network model was suggested in this study.
Keywords: *backpropagation, neural networks, normalization, route choice*

1. Introduction

The traffic assignment problem is one of the most important issues encountered by transportation experts. During past three decades, many researches have been done to solve the problems concerned with traffic assignment among routes. The artificial neural network has recently been applied in many areas including transport engineering and planning, and has provided better results than traditional methods (Dougherty, 1995; Ledoux, 1997; Shmueli *et al.*, 1996). For the Estimation of Drivers' Route Choice, Kim *et al.* (2002) showed that the Neural Networks could be more efficient than a Logit model.

Even though the neural network models have been used successfully for transportation area, there are some major issues to be considered before using the model, such as the network topology, learning parameter, and normalization methods for the input and output vectors. For the multilayer feedforward using Backpropagation learning algorithm, usually simply called Backpropagation, which is the most popular neural network model, normalization method for input vectors could effect to the prediction performance (Kim, 1999). In Kim (1999), the requirement of normalization for the input and output vectors on Backpropagation has been studied theoretically, and different normalization methods have been considered, in order to see how each normalization method effects the performance of a Backpropagation neural network in a pattern recognition problem. Even though he showed that the normalization method is highly dependent.

However, the normalization method could be different according to properties of input data and the best normalization method for each problem should be developed in order to achieve the best performance. In this research, several normalization methods have been studied to achieve the best performance for the estimation of drivers' route choice model. The performance of Backpropagation neural network model in terms of predictive accuracy has been compared on the test data sets through experiments with real world route choice behavior data.

2. Backpropagation and Normalization

2.1. Backpropagation Model

The Backpropagation proposed by Rumelhart *et al.* (1986) is an error-correcting learning procedure that generalizes the delta rule to multilayer feedforward neural networks with hidden neurons between the input and output vectors. The training process is to determine the weight vector that minimize an error function.

During the feedforward calculations, two mathematical operations are performed by each neuron; the first is a linear component that computes the weighted sum of the node's input value (Σ), and the second is a non-linear component that transforms the weighted sum into an output value using an activation function, $f(\ )$.

While the computation for output of each neuron is working forward from the input to the output layer, the error at the output of every layer is propagated back to the previous layer, and the weights are changed to decrease that error. Mathematically, the feedforward processing can be written as follows.

Define input vector to the network $\mathbf{x}_p = (x_{p1}, x_{p2}, x_{p3}, \ldots, x_{pK_0})^T$

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