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Multilayer feedforward networks for transportation mode choice analysis: An analysis and a comparison with random utility models

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Abstract

Usually, discrete choice analysis as regards a transportation system is based on random utility theory. Recently, a different approach to choice analysis, based on Artificial Neural Network (actually a multilayer feedforward network—MLFFN) models, has been proposed by several researchers. Such modelling approach can address three main demand simulation issues (trip generation, trip distribution and modal split) and has shown good predictive capability. Most of the papers deal with extra-urban (inter-city or intra-regional) trips and they are calibrated on aggregate data, simulating demand flows, results have been compared with regressive models. An alternative and more stimulating approach can be followed up by using disaggregate data, as only one paper does, to simulate single-user choice. The aim of this paper is twofold, first to describe the main step towards the successful application of MLFFNs to support travel demand analysis, and second to show that they can be fruitfully applied to analyse transportation mode choice. A deep analysis has been carried out to address each of the major issues needed to make operational an MLFFN. The proposed approach relies on disaggregated (revealed preferences survey data-sets) data taken from two different case studies. The two case studies focus on medium distance intercity journeys, and allow to investigate mode choice for two different trip purposes and two different geographical contexts: journey-to-work of commuters within the Italian region of Veneto and journey-to-study of students towards the rural location of the University of Salerno. MLFFNs performances have been compared with the most effective and advanced closed-form Random Utility Models (RUMs) that can be calibrated on the

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same survey data-sets. Models validation and comparison have been carried out by using indices commonly used in MLFFNs or RUMs applications, and by introducing many others expressly defined to aid results interpretation.

Keywords: Choice modelling; Artificial neural network; Multilayer feedforward network; Random utility theory; Transportation mode choice

1. Introduction

Usually, discrete choice analysis as regards a transportation system is based on random utility theory (Domencich and McFadden, 1975; Ben Akiva and Lerman, 1985; Cascetta, 2001).

Recently, a different approach to choice analysis, based on Artificial Neural Network models[2] (see for a review Khanna, 1990), has been proposed by several researchers (Reggiani and Tritapepe, 1998; Nijkamp et al., 1996; Schintler and Olurotimi, 1998; Shmueli, 1998; Shmueli et al., 1996; Mozolin et al., 2000). The cited papers address three main demand simulation issues (trip generation, trip distribution and modal split) and have shown good predictive capability. They all deal with extra-urban (inter-city or intra-regional) trips and they are calibrated on aggregate data, simulating demand flows (generated flows from each origin, origin–destination flows, and mode shares for each origin–destination pair), results have been compared with regressive models.

Hensher and Ton (2000), more recently, have proposed an alternative and stimulating approach, using ANN (actually a multilayer feedforward network) models to simulate single-user choice in an urban context. These models are specified and calibrated on disaggregate stated preferences (SP) data and compared with nested logit models.

The aim of this paper is twofold, first to describe the main step towards the successful application of artificial neural networks to support travel demand analysis, and second to show that they can be fruitfully applied to analyze transportation mode choice.[3] The proposed approach is based on multilayer feedforward networks (MLFFNs), as in the cited papers.

A deep analysis, with more details than cited papers, has been carried out to address each of the major issues needed to make operational an MLFFN: the split of survey data-set into calibration and validation data-sets (step 0), the number of epochs and the number of the starting conditions to gain an effective application of the (back-propagation) calibration algorithm (step 1), the definition of the MLFFN architecture that is number of hidden layers, number of processing units per layer, types of activation function per processing unit/layer (step 2), and finally the selection of the representative parameter set for the selected architectures (step 3). In addition, several indices have been used to carry out model validation and comparisons, including some new ones. The

[2] Much effort from the AI community, specially, the Multi-agent community has been dedicated toward finding adequate means to represent and to aid the understanding of an individual's cognitive process, such as the BDI (beliefs–desires–intensions) approach. Several other approaches have been proposed for discrete choice analysis, for instance those based on fuzzy sets, but are still at research stage.

[3] This is an application of traditional ANN techniques since any development in the specification process was out of the scope of this paper.