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Comparing direct transferability of Logit and Fuzzy logic models of gap acceptance at unsignalized intersections

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Abstract

This paper presents a comparative analysis of the performance of Logit models vs. Fuzzy logic models of gap-acceptance behavior in terms of their direct transferability. This refers to situations in which a model estimated in a given experimental context is directly applied in a different context without any updating. Data collected at four priority intersections having different characteristics in terms of geometry, location and type of control (stop vs. yield sign) were used to test the quality of the results obtained when transferring each type of model from an original to an alternative situation. The comparison was carried out based on metrics commonly used in the so-called ROC (Receiver Operating Characteristic) curve analysis. The results show that both models have essentially the same capability in terms of direct transferability, and that their performance in contexts different from those of original development could be more than adequate for application purposes.

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Keywords: model transferability; gap acceptance; Logit models; Fuzzy logic models.

1. Introduction

In studies of vehicular gap-acceptance behavior, the choice to accept or reject a gap of a certain size is generally considered the result of a driver decision process which includes, as inputs, subjective estimates of a set of explanatory variables, given specific objective factors. These subjective evaluations are usually affected by a high degree of uncertainty, which can be properly treated both by classical probabilistic models (Cassidy et al. 1995, Teply, Abou-Henaidy & Hunt 1997a, Teply, Abou-Henaidy & Hunt 1997b, Maze 1981, Rossi, Meneguzzer &

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Gastaldi 2013) and by fuzzy system theory (Rossi, Meneguzzer 2002, Rossi et al. 2010, Rossi, Gastaldi & Gecchele 2011, Rossi et al. 2011a, Rossi et al. 2011b, Rossi, Gastaldi & Gecchele 2014); calibration and validation of these models is usually based on gap-acceptance data collected at real intersections using, for instance, observations based on video surveys.

The primary objective of the present work is to evaluate, with reference to both type of models, the possibility of performing a successful transfer from an original context to a different context (direct transfer). Two advantages of model transferability are to reduce the efforts in model development (using the same structure of the model previously identified) and to reduce or eliminate the need for a large data collection in the application context (Rossi, Meneguzzer & Gastaldi 2010, Rossi, Meneguzzer & Gastaldi 2013). In particular, this is related to the practical requirement to include in micro-simulation models or, more generally, in intersection operational analysis, behavioral models (for instance, car-following, lane merging, and gap-acceptance) easily adaptable to different contexts.

The effectiveness of the full model transfer (direct transfer), which does not involve any updating of model knowledge base, was analyzed. Gap-acceptance data were collected at four intersections with a video survey system and then used for building four corresponding Logit and fuzzy gap-acceptance models. Each of these models (called "original") was directly transferred to the other three intersections (called "application contexts") and the capability of these transferred models to represent the real behavior (drivers' gap-acceptance decisions) was validated using the corresponding gap-acceptance data collected in the application contexts.

A comparative analysis among locally built and transferred models was performed. The method used to carry out this comparison is the so-called ROC (*Receiver Operating Characteristic*) curve analysis (Fawcett 2006); the objective of the analysis is to evaluate the performance of the transferred models and the locally built models in terms of their ability to predict the real behavior of drivers in gap-acceptance situations.

The paper is organized as follows. Section 2 briefly summarizes literature on the analysis of gap-acceptance behavior and on model transferability. Section 3 introduces the study sites and describes the experimental data used in this study. Section 4 and 5 describe the main characteristics of the Logit and fuzzy gap-acceptance models under analysis. Section 6 presents the application of ROC curve analysis to the evaluation of the transferability of gap-acceptance models. Concluding remarks and future developments are presented in Section 7.

2. Previous work

The gap-acceptance problem considered in this paper refers to the situation in which a driver, starting from the secondary approach of a priority intersection, wants to perform a crossing or merging maneuver into a primary road. Gap is the time interval between two successive vehicles of the major stream; lag is a residual part of a major-stream gap measured from the time when the minor-stream driver arrives at the stop line (and starts the gap selection) until the next major-stream vehicle arrives to the conflict point.

Essentially, this requires the choice between two mutually exclusive alternative actions: to accept or reject a gap (or lag) of a given time size in the primary traffic stream. Evidently, such a choice is the result of a decision process affected both by driver characteristics (for example, driving experience, gender and age (Wennell, Cooper 1981, Teply, Abou-Henaidy & Hunt 1997a, Teply, Abou-Henaidy & Hunt 1997b)) and characteristics of the gap/lag and of the choice situation (for example, gap/lag size, waiting time and speed of vehicles on the primary road (Adebisi, Sama 1990, Polus, Kraus & Reshetnik 1996)). Thus, as shown by several previous studies, gap-acceptance behavior varies among drivers and, for the same driver, over time.

Fuzzy set theory-based and probabilistic discrete choice models (e.g. Logit models) have been considered to be appropriate for modeling the choice behavior under examination (Maze 1981, Cassidy et al. 1995, Teply, Abou-Henaidy & Hunt 1997a, Teply, Abou-Henaidy & Hunt 1997b, Pollatschek, Polus & Livneh 2002, Rossi, Meneguzzer 2002, Toledo 2007, Rossi et al. 2010).

In general terms model transferability (spatial and/or temporal) refers to situations in which a model specified and estimated in a given original (estimation) context is subsequently transferred and applied to another (application) context. This operation should have two primary advantages:

- to reduce the efforts in model development (using the same structure of the model previously identified);
- to reduce or eliminate the need for a large data collection in the application context.