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Using Decision Trees to Determine Junction Design Rules

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Many contemporary design manuals for roads contain guidelines for designing junctions in urban traffic networks. These guidelines often contain a set of rules to determine the best junction design for a specific situation, based on rules of thumb and/or relatively simple assessment schemes. The rules are used to determine the main junction type and major design variables such as the number and configuration of the approach lanes, the handling of bicycle and pedestrian priority and the traffic signal settings. Input to these rules are the traffic flows on the junction. Junction design rules have been developed in numerous countries and although they are based on many years of experience they are ambiguous in multiple ways. The rules often, and mostly unintentionally, combine multiple criteria and objectives and prescribe different levels of detail for the modelling of junction performances. Moreover, a limited number of design alternatives is considered, which increases the chances that the 'best' alternative is not found. Furthermore, little is known about the measurable impact of the rules on the performance of traffic networks and their contribution to maximising accessibility and minimising the negative effects of traffic related to traffic safety and environmental impacts. There is a growing need for unambiguous junction design rules for urban networks which can be used to systematically assess multiple objectives on both local and network level. The research described in this paper is the first step in order to attain these unambiguous junction design rules.

In this paper an approach is presented in which junction design rules are determined, in a systematic manner, by using decision tree learning methods. For the time being, the rules are based on the performances of isolated junctions and the performance measures are limited to serving maximizing accessibility.

In order to determine junction design rules one needs a lot of data with different traffic flows, different junction designs and various performance measures. This kind of data is not available, partly because only one or a few junction designs are actually realised on a specific location but mostly because junction design influences travel behaviour, resulting in adjusted traffic flows. Alternatively, one can use a junction model to determine the junction performances for a multitude of traffic flow configurations and junction designs. In this research the Highway Capacity Manual 2010 approach is used to determine the junction performances. This macroscopic analytical approach is chosen due to its international recognition and the fast calculation times. The latter is inevitable since the number of traffic flow and junction design combinations to test is large. About 60 different junction designs and about 500 different traffic demand configurations are tested, resulting in 30.000 situations to model.

In this research decision tree learning is used to determine junction design rules based on the generated data. The procedures are used to create decision tree classification models in which the junction design (one of the 60 design alternatives) is the dependent (target) variables based on

values of the independent (predictor) variables, mainly being the traffic flow configuration variables. The input data was derived from the model generated data by determining the junction design with the minimum performance measure, e.g. the overall (volume-weighted) delay, for each traffic flow configuration and size category. The latter was added to prevent the fact that the largest junction design always is the best. Various growing methods, such as CHAID, Exhaustive CHAID, C(A)RT and QUEST are tested on the risk estimates and various percentages of correct classification as well as tree complexity. The methods are optimised by adjusting parameters concerning the split and stop criteria, pruning methods and the use of misclassification costs. Decision trees are generated for varying performances measures.

The misclassification ratio and the actual junction performances for the best decision tree method are compared with the results of junction design rules from various international design manuals. The results show promising directions for improvements in junction design rules.

The research in this paper is part of an ongoing PhD-project concerning the determination of junction design rules for urban traffic networks. The first step is to extend the research to performance measures concerning traffic safety and environmental impacts. A next step is to determine the network effects of existing and newly generated junction design rules. By analysing the (multi-objective) optimal network solutions, network rules could be added to the decision trees.

Short description

In this paper an approach is presented which determines unambiguous junction design rules for urban traffic networks by using decision tree learning methods based on data generated by a HCM 2010 based model.