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Improving Traffic Conditions on a Set of Three Intersections Using Microscopic Simulation Models

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Abstract

This paper presents a method for defining and improving the traffic conditions in a set of cross section in the city of Cluj-Napoca, using microsimulation software for the traffic. Simulation models are designed to mimic the behavior of traffic in a time and space transport system in order to predict the system's performance. A simulation model studies a real world system, considering mathematical and logical concepts associated with the system operation and analyzes them using complex computer programming. Each simulation model presents a set of advantages such as: it can be more accurate than an analytical approach, it is able to test new conditions, it can improve the perspective concerning the significance of variables and of the way these variables interact. A case study is presented, using a set of three street intersections. In these intersections measurements of traffic during morning peak hours were performed. The measurements were acquired both manually and automatically, using time slots of 15 minutes each. The collected data was also used for model calibration. With the help of microsimulation software and a well-balanced model, information regarding traffic conditions can be found, resulting in analyses of the traffic evolutions. Some traffic conditions issues are identified and a set of improvement suggestions are presented. The measures proposed in this paper need to be tested and further optimized also by means of microsimulation, before being implemented, in order to obtain satisfactory results. The area under investigation exhibits quite large delays in traffic, in present-day conditions. This means smaller displacement speed, and, implicitly, more toxic emissions, that make the system be farther from the idea of sustainable transportation.

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Keywords: traffic; microsimulation model; traffic delay; average speed; waiting line.

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1. Introduction

Road traffic involves complex processes easy to understand apparently, though their analysis, planning and functioning represent true challenges. The system often covers a wide range of areas, a large number of participants, both vehicles and pedestrians. There are two main approaches used to model such a complex system, an analytical one and simulation-based models.

The simulation models are designed so as to mimic the traffic behaviour, in a transport system in time and space that enables the forecasting of the system performances. A simulation model studies a real world system, taking into account the mathematical and logical concepts associated to the system operation and performs an analysis making use of complex information technology programming [1]. Traffic simulation models are effective tools for evaluating the behavior of vehicles, pedestrians and commercial traffic operations. These tools can be used to assess various scenarios and also to visualize and analyze current traffic conditions [2], [3].

Simulation models present a set of advantages: they can be more accurate than analytical approaches, they can make tests for new conditions, they can improve the perspective concerning the significance of variables and of the way these variables interact [4]. Microsimulation represents the dynamic and stochastic modelling of the movements of individual vehicles within a transportation system. These models are thus widely admitted in the traffic management at an operational level. Microsimulation can provide benefits compared to conventional traffic analysis methods, in three sides: clarity, accuracy and flexibility [5]. Simulation models have been successfully used for evaluating safety performance of urban signalized intersections [6], assessment of level-of-service for freeway segments [7], calculating NOx emissions [8] and many other applications.

2. Research methodology

The Highway Capacity Manual (HCM) contains a stochastic simulation model that can successfully integrate the statistical model and also the analytical model [9]. Besides a regression model and a gap-acceptance model, microsimulation can predict roundabout performance. The algorithm behind the microscopic simulation is based on the vehicle-following theory and lane-changing behavior. Types of existing microscopic traffic simulation models are SimTraffic, VISSIM, AIMSUN, CUBE Dynasim, and others [10].

The software used for the purpose of this paper to create a microsimulation model is Vissim. This is a commercially available model for microsimulating the traffic used for modeling urban traffic and operations of public transport in various directions.

Different from less complex models, based on constant speed, VISSIM uses the behavioral model of the driver, developed at psychological and physical level by Wiedemann. A vehicle of speed x_{i+1}, which is higher than speed x_i, of another vehicle situated previously, will overcome the latter as it comes neared to the latter at a constant difference of speed Δx. When reaching the perception limit, the follower driver will decrease the speed. The reduction of the speed has the shape of a parabola if deceleration is constant. When braking, the driver tends to get to a point where $\Delta x = 0$. However, this situation cannot occur as there is no exact perception of small differences in speed and the speed of the vehicle cannot be accurately controlled [11].

Consequently, the distance between the vehicles will increase again and the driver will try to accelerate to keep a constant distance. Considering that the perception limit of the positive and negative relative speeds remains at the same level, it yields that a permanent switching around the desired speed relative to the followed vehicle occurs (see Fig. 1). These modes are determined using the following six thresholds [12]:

- AX – the desired distance between two stationary vehicles;
- BX – the minimum following distance considered as a safe distance by drivers;
- CLDV – the points at short distances where drivers perceive that their speeds are higher than their lead vehicle speeds;
- SDV – the points at long distances where drivers perceive speed differences when they are approaching slower vehicles;
- OPDV – the points at short distances where drivers perceive that they are travelling at a lower speed than their leader vehicle;
- SDX – the maximum following distance indicating the upper limit of car-following process.