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Utilization of cellular automata for analysis of the efficiency of urban freight transport measures based on loading/unloading bays example

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Abstract

The analysis of urban freight traffic is a difficult research area, due to the following major reasons: a big number of factors that prevent a clear definition of its characteristics and lack of data regarding the traffic flows, classification of vehicles, vehicles routes etc. The above influence on problem with analysis of the efficiency of urban freight transport measures. Computer simulation could be significant helpful in this area. The main objective of this paper is to introduce usability of cellular automata as the tool for simulation of traffic in urban freight transport systems. The basis of the analysis will be the example of utilization of loading/unloading bays. Presented simulation will help to analyse the efficiency of this measure as well as its potential influence on city environment.

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Keywords: urban freight transport; city logistics; simulation; modelling; cellular automata.

1. Introduction

The analysis of urban freight traffic is a difficult research area, due to a number of factors that prevent a clear definition of its characteristics and lack of data regarding the traffic flows, classification of vehicles, vehicles routes etc. Additionally, an important role in it plays the human factor and problems with clear definition of human behavior. The above influence on problem with analysis of the efficiency of urban freight transport measures and its

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influence on city environment. However, the vehicle traffic is based on space-time link, which may be determined by mathematical functions. Due to that computer simulation could be significant helpful in this research area. Therefore, simulation allows for building mathematical models, which link input parameters to obtain a certain result at the system output (Gordon 1974). Numerous publications on this subject is focused especially on traffic research and modelling, developing theory and traffic models as well as the research on behavior of traffic participants (Chowdhury *et al.* 2000; Helbing 1997; Kerner 2001;May 1990; Daganzo 1993; Wolf *et al.* 1996; Wolf and Schreckenberg 1998).

It's possible to identify two major types of simulations:

- discrete time simulation, which is used to test the behavior of real and hypothetical systems
- continuous time simulation, which is generally used to test systems, dominated by changes of a permanent nature.

The basis of the simulation process introduced in this paper is first type of simulation. Discrete time simulation to analyze urban freight transport measures is particularly useful due to reasons mentioned below:

- gain a lot of information about the system already in the design phase, so that the answers to some questions about the functioning of the system can be obtained without having to build it and test it (e.g. by trial and error);
- carry out research on the system behavior under various conditions, even those that are difficult to obtain in reality (e.g. those which are rare), or even those that do not actually exist (it is possible due to the identification of simulation objective and adaptation of input parameters);
- carry out a number of tests at low cost (computer simulation is a process that can be repeated easily, usually without incurring additional costs);
- shorten simulation time depending on the computing power;
- carry out research on real and hypothetical systems, enabling the development of new more efficient systems;
- determine the usefulness of the system depending on the results obtained, where, in the case of a negative result, the cost incurred to perform the simulation is not as large as in the case of actual system construction, testing and decommissioning.

Presented model will be prepared with the utilization of cellular automata. Cellular automata are considered by some researchers as one of the computer science area, which is an artificial intelligence. The universality of cellular automata led to their application in many areas such as: physics, computer graphics and traffic modelling. This is kind of discrete time simulation process, due to that it's very helpful for analysis of traffic flows in urban freight transport systems. The most important result from the research presented in the paper is the introduction of this simulation method for analysis of the efficiency of urban freight transport measures. It could be used in many other examples, focused on traffic influence on the UFT functioning, like UFT routing, ITS utilization in UFT etc. Results of simulation could help to assess the environmental impact of UFT, based on scenario approach.

2. Loading/unloading bays as the measure, which could reduce the negative impact of urban freight transport on city environment

Loading/unloading bays (or, in other words, slots) are one of the most popular measures, implemented in cities to support realization of deliveries. It aimed at reducing traffic congestion on busy city streets that is created by freight vehicles parking directly in the street area when they load or unload goods for shops or make home deliveries. By designating special parking bays/slots for freight vehicles traffic would be able to flow again and thus avoid the extra energy and fuel consumption, pollution, time and costs that traffic jams typically create. This is pull type measure, based on administrative activities and close cooperation ben city authorities, freight carriers and shippers (Bourn and MacDonald 2012).

The main strength of this measure is that it effectively reduces congestion effect due to that loading or loading/unloading operations are realize in special area and not influence directly on traffic flow. Also, the costs for setting up the loading/unloading bays are very low so that this is a very cost effective measure for the municipality. A major weakness of this measure is that parking space for loading/unloading bays is taken away from passenger