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Transportation Research Procedia 16 (2016) 329 – 342

Transportation Research Procedia

www.elsevier.com/locate/procedia

2nd International Conference "Green Cities - Green Logistics for Greener Cities", 2-3 March 2016, Szczecin, Poland

The importance of automatic traffic lights time algorithms to reduce the negative impact of transport on the urban environment

Małecki Krzysztof *

West Pomeranian University of Technology, Żołnierska Str. 52, 71-210 Szczecin, Poland

Abstract

This paper focuses on the aspect of traffic lights control in order to reduce congestion and thereby contribute to the reduction of the negative impact of transport on the urban environment. The author presents his thoughts based on automatic traffic lights time algorithms developed and presented in the article. The effectiveness of the algorithms was tested in a developed cellular automata based traffic simulator.

Peer-review under responsibility of the organizing committee of Green Cities 2016.

Keywords: traffic optimization; traffic lights optimization; reducing the negative impact of transport in the city; algorithms; cellular automata; multi-agent systems;

1. Introduction

The world around is not static. It changes over time, evolves just as its individual components. In order to know how the environment behaves to changes in any parameters, there are two paths to choose from - make changes in the surrounding environment and observe the reaction or build a copy of the environment as close as possible to the reality and then test its response to the introduced changes. The problem here is, however, the complexity of the environment that surrounds us. It is not cost effective, and often physically impossible to make a copy of the environment in the real world and then let it be destroyed. In this case, technology becomes helpful. If you cannot make a copy on a 1:1 scale, you should gather as much information about the environment as possible and recreate it virtually, i.e. build a model of the system. Of course, it is not possible to simulate the world around us at any scale. System created in such

* Corresponding author. Tel.: +48-91-449-55-14; fax: +48-91-449-56-61.
E-mail address: kmalecki@wi.zut.edu.pl

Peer-review under responsibility of the organizing committee of Green Cities 2016.
doi:10.1016/j.trpro.2016.11.032

way will reproduce only its selected section. Modeling and simulation is applicable in every area of life, and recently it has become increasingly popular in the study of traffic changes. By using more accurate mathematical models used to describe the movement, it is possible to carry out tests and avoid errors before they are implemented by physical interference with the existing structure of the road. Therefore, each studied solution is a new model, the behavior of which is tested under the conditions specified for the simulation. In the case of modeling and simulation of traffic there is, however, another variable - control of simulated traffic on modeled road section or road junction. It requires a driver, whether in the form of a man - an expert, whose task will be to control the movement of vehicles or machine generating signals for them. The obtained results depend to a large extent on this factor. Therefore, it is important to choose the appropriate control algorithm and its subsequent adaptation to the prevailing conditions. This publication shows the above issues and presents the results of research carried out using original software based on the developed algorithms for automatic traffic lights modulation in order to increase road capacity and thus reduce the negative effects of urban transport i.e. air and noise pollution emitted by vehicles and congestion .

Traffic simulation was made based on traffic models, supported by the theory of cellular automata, Wolfram (2002). Traffic lights control has been enhanced by multi-agent control system by Wooldridge (2002). The entire road system has been treated as a dynamic system by Grogono (2005), Scheinerman (2012), Wilensky and Resnick (1999), which simply means the system evolving over time. Aspects of "green transport" have been shown in Wątróbski and Sałabun (2016).

1.1. The negative impact of transport on the urban environment

Various publications have focuses on the estimation of the level of pollutants in transport, which include e.g.: Gronowicz (2004), Taniguchi et al. (2001). Table 1 shows the components of exhaust gases by types of engines and their emissions depending on the engine operation.

Table 1. Components of exhaust gases at different engine operating conditions (ZI - positive ignition engine, ZS - compression ignition engine).

Components of exhaust gases	Idle speed		Acceleration		Constant speed		Braking	
	ZI	ZS	ZI	ZS	ZI	ZS	ZI	ZS
Carbon monoxide [%vol.]	1,3-14	0	3	0,05	3,4	0	5,5	0
Hydrocarbons [%vol.]	0,16-0,98	0,02-0,05	0,09	0,02	0,03	0,01	1,67	0,03
Nitrogen oxides [ppm]	15-45	50-68	1347	849	653	237	18	30
Aldehydes [ppm]	5-72	6-17	16	17	7	11	289	29

Source: Gronowicz (2004), p. 111.

This summary can serve as a basis for focusing attention of designers of new solutions on factors that have a greater effect on the reduction of the amount of pollutants. The negative impact of transport and the ways of prevention and the implementation of good practices has been discussed by Iwan and Kijewska (2014). Reduce the impact of negative factors believed to be in electric motors, electric vehicles and hence renewable energy sources, discussed by Iwan et al. (2014), Watrobski et al. (2016), Wątróbski and Sałabun (2016). The context of the driving techniques optimization in order to reduce the number of acceleration and braking, which translates into a reduction of environmental load was discussed by Forczmański and Małecki (2013). The author also knows the articles dedicated the detection of vehicles in intelligent monitoring systems, which can translate into the assessment of traffic, vehicle counting and classification. And this in turn allows for verification of vehicles being in separate, ecological areas of cities. These aspects are dealt eg. by Frejlichowski et al. (2016) and Nowosielski et al. (2016).

1.2. Road junction as a dynamic system

Any road junction, and even a section of straight road can be seen as a dynamic system, because it evolves over time (traffic varies at different times of the day, weather changes). It is possible to extract the states of this system - e.g. values describing the number of vehicles per hour. The situation on the road (just as in the case of a system) can