Silesian University of Technology
Faculty of Transport

Transport Problems 2016

Proceedings

VIII International Scientific Conference
V International Symposium of Young Researchers

UNDER THE HONORARY
PATRONAGE OF THE SILESIAN GOVERNOR
AND MAYOR OF KATOWICE CITY

ISBN 978-83-935232-8-3

Transport Problems
International Scientific Journal

Silesian University of Technology
Publication
Faculty of Transport

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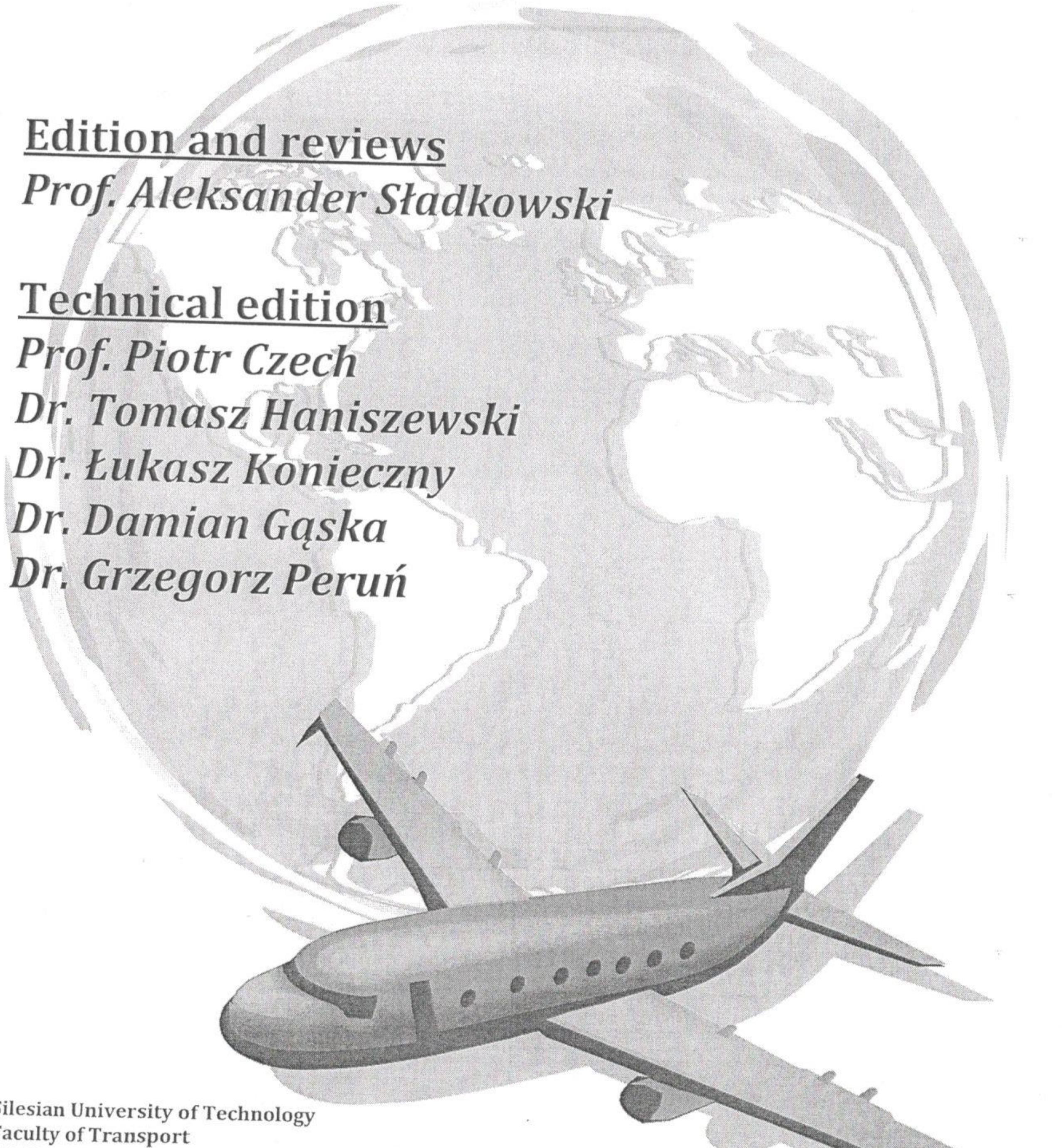

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VIII INTERNATIONAL CONFERENCE TRANSPORT PROBLEMS 2016

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micro-simulation model; modeling; traffic simulation systems;
comparative analysis; SWOT analysis;

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A COMPARATIVE ANALYSIS OF EDUCATIONALLY DEVELOPED MICROSCOPIC TRAFFIC SIMULATION MODEL - SFSTREETSIMODEL, VERSION 2.1

Summary. Micro-simulation is the modeling of individual vehicle movements on a second by second or sub second basis for the purpose of assessing the traffic performance of highway and street systems, transit, and pedestrians. The past one and a half decade a rapid evolution in the sophistication of micro-simulation models have been seen, as well as a major expansion of their use in transportation engineering and planning practices. Models of the mid-nineties required inputs which were expensive to collect and not accurate enough to reflect the full range of traffic behavior. Trough introduction of new technologies for advanced traffic control and information systems next generation models abound a source of data which can be used to reduce the cost of collecting the required data and improving its fidelity. In this context this paper aims to perform as an overview that combines both, current traffic simulation systems capabilities and customer expectations. Therefore, a comparison of simulation tools as well as SWOT analysis has been conducted by analyzing scientific papers and technical specifications. Namely, we will present a comparative analysis between recently developed microscopic simulation model SFSTreetSIModel, version 2.1 for educational purposes and three commercial micro-simulation tools.

1. INTRODUCTION

Traffic congestion increases travel times, traveler stress and accident rates, reduces mobility, accessibility, and system reliability, and results in loss of productivity and environmental degradation. Simulation of traffic as a tool for investigating traffic systems has increased in popularity over the last two decades. The analytical tools required to support these efforts need to provide a detailed assessment of how traffic operates and travelers respond to system impacts. Unfortunately, traditional macroscopic models are generally ineffective in evaluating strategies designed to influence travel choices and optimize system performance (as for e.g., level of service). In particular, traditional four-step models cannot capture traffic dynamics, queue length, delays, vehicle–pedestrian interactions, geometric design impacts, street furniture impacts or traveler and pedestrians responses.

As a result, simulation-based models are being recommended to aid traffic and transportation planners, designers, and policy-makers in assessing future needs and mobility options. The Traffic Simulation Systems evaluation process included two independent assessments. While one focused on Traffic Simulation Systems features, the other one tried to collect customer expectations and needs on Traffic Simulation Systems. In general, most of the authors careful on simulation model goals and development (principles modeling), calibration with field data, validation, simulation and animation, output parameters, and consistency with HCM methodologies, and in recent years and analysis of air quality, fuel consumption and exhaust emissions. It is clear that there are different driving forces, like there are main factors influencing research in simulation. These forces could be described as:

- advances in traffic theory,
- continuous improvement computer hardware,
- continuous improvement software,
- development of the general information infrastructure, and
- society's demand for more detailed scenario analysis.

In general, the key advantages of micro-simulation tools can be traced to their ability to:

- Model different vehicle types;
- Consider temporal and spatial interactions;
- Consider traffic dynamics;
- Model different behavioral assumptions and user classes;
- Visualize how proposed alternatives will operate.

Despite these advantages and capabilities, there is still significant debate among transportation professionals and decision-makers about the benefits of micro-simulation modeling. Some decision-makers are not convinced that micro-simulation results are reliable or comprehensive enough for major capital investment decisions. Others have yet to see effective returns from the investment in micro-simulation due to the amount of effort required to code, calibrate, and apply the model.

2. TRAFFIC SIMULATION SYSTEMS - STATE-OF-THE-ART

Previous comparisons of micro-simulation programs have been conducted by Brockfeld et. al. (2003)[1], Bloomberg et al. (2003)[2], ITS University of Leeds (1997-2003)[3]. The outcome of their comparisons was an evaluation of the simulation programs ability to fit real traffic data from the test area. They found that none of the tested models produced better or worse results than the other. Moreover, all models generated results consistent with the methodologies used in the Highway Capacity Manual 2010, Transportation Research Board [4].

Traffic simulation tools are generally classified based on three levels of detail, namely, microscopic, mesoscopic, and macroscopic. Micro-simulation models are essentially research products. In general, most of the authors in the analysis and choice simulation model, careful on his goals and development (principles modeling), calibration with field data, validation, simulation and animation, output parameters, and consistency with HCM methodologies, and in recent years and analysis of air quality, fuel consumption and exhaust emissions.

According to the prepared review below, developed microscopic simulation model SFStreetSIModel, version 2.1 whose main goal and development is the analysis of traffic flow performances related on the primary and secondary street network, as well as system safety and environmental measures, it will be compared to micro-simulation models HUTSIM (Helsinki Urban Traffic Simulation) and NETSIM (Network Simulation - part of CORSIM (Corridor Simulation), models that are related to primary urban networks, and therefore are more complex than SFStreetSIModel,version 2.1 but according to their properties, objects and phenomena modeled show the highest level on suitability for comparative analysis.

3. SFStreetSIModel, version 2.1, BASIC CHARACTERISTICS

Side Friction Street SImulation Model - SFStreetSIModel is an object-oriented, microscopic, discrete model [5]. SFStreetSIModel simulates the dynamics of passenger cars and light commercial vehicles flow on a two lane-two way street section, as well as the progress of pedestrians along the sidewalk street section. The surrounding street structure including on-street parked vehicles, waste baskets and containers, advertising boards and trees, has also been modeled and visualized, with objects being generated in the model according to the appropriate distributions. Their parameters are modeled as discrete distributions. The decision on the manner they proceed their movement has been made in compliance with the appropriate logical variables.

The application of the developed model and its fulfilled version 2.1., will hopefully have both scientific and practical contribution for the developing countries. In spite of the enormous progress these countries have made during the last ten years, the low infrastructure capacity and design are unfortunately still present there. As a matter of fact, the complex street environment structure seems still rather persistent with street furniture objects or parked vehicles often seen on the street profile, which undoubtedly, influences traffic flow parameters, safety and effectiveness.

3.1. SFStreetSIModel, version 2.1 vs. HUTSIM vs. NETSIM vs. FREESIM: basic features

In order to compare micro-simulation models properties, objects and phenomena modeled a theoretical review has been carried out. This section described the outcome of it.

Tab. 1

Comparison of the basic simulation features

FEATURE	SFStreetSIModel	HUTSIM	NETSIM	FREESIM
level of detail	Microscopic	Microscopic	Microscopic	Macroscopic
dimension	Stochastic	Stochastic	Stochastic	Stochastic
model type	Discreet	Discreet	Discreet	-
Objects and phenomena modeled	Yes	Microscopic	Yes	Yes
interaction with external codes	No	Planned	No	Yes
graphical presentation (friendliness)	Yes	Yes	Yes	Yes
animation	2D	3D	2D	2D

Source: Authors

Tab. 2

Comparison of the calibration parameters

calibration parameter	SFStreetSIModel	HUTSIM	NETSIM	FREESIM
time steps < 1.0 second	No*	Yes	No	No
Gap acceptance criteria	Yes **	No	Yes **	Yes *
Gap acceptance	Based on vehicle class	Yes	Based on vehicle class	No information
Safety distance	Based on vehicle class and other safety distances	Yes	Based on vehicle class	No information

* = 1 second

** = within the lane-changing process, based on the safety distances

Source: Authors

Tab. 3

Comparison in terms of interactions between objects, objects and phenomena modeled

	SFStreetSIModel	HUTSIM	NETSIM	FREESIM
Object / phenomenon	Objects and phenomena modeled			
Car-following, overtaking and lane changing logic	Yes	Yes	Yes	Yes
user x-y position (maneuver patterns)	Yes	Yes	Yes	Yes
Variable reaction time	No	Planned	No	Planned
Variable acceleration	Yes *	Yes	Yes	Yes
Headways	Yes	No information	No	Yes
Weather conditions	No	No	No	No
Driver perception	Yes	No information	No information	No
Parked vehicle	Yes	No	Yes	No
Commercial vehicle	Yes	Yes	Yes	Yes
Bicycles	No	Yes	No	Yes
Pedestrians	Yes **	Yes	Yes	Yes
Public transports	No	Yes	Yes	No
Incidents	No	Yes	Yes	No
Adaptive traffic signals	No	Yes	Yes	No
Co-ordinated traffic signals	No	Yes	Yes	No
Variable message signs	No	Yes	No	No
Streetscape interaction obstacle detection	Yes	No information	No information	No
Road user interaction	Planned	Yes	No information	Yes

* in function of the concentration of the side obstacles and distance to them; ** on sidewalk Source: Authors

Tab. 4

Comparison in terms on Comfort and Performance objectives

Objectives	SFStreetSIModel	HUTSIM	NETSIM	FREESIM
Efficiency	• Travel time • Speed • Concentration • Flow • Congestion • Queue length • Level Of Service	• Travel time • Travel time variability • Speed • Congestion • Queue length	• Travel time • Travel time variability • Speed • Congestion • Queue length	• Travel time • Travel time variability • Speed • Congestion • Queue length
Safety	• Number of overtaking's	• Headway • Number of accidents • Accidents severity • Interactions with pedestrians	No information	• Headway • Number of accidents • Accidents severity • Interactions with pedestrians
Environment	• Exhaust emissions • Fuel consumption	• Exhaust emissions • Fuel consumption	• Exhaust emissions • Fuel consumption	• Exhaust emissions • Fuel consumption

Source: Authors

4. SWOT ANALYSIS

Within this paper, a state-of-the art review has been drawn up. All four simulation models had strengths and weaknesses that made it suitable for certain applications, as well as to estimate current traffic situation and predict traffic conditions as for example traffic congestion. Most systems are designed for the use in "urban" road networks. These systems are additionally able to deal with real-time traffic data. However, every system tries to deliver huge amounts of functionalities but fail by providing all functionalities. Some of the traffic simulation systems have limitations in links, etc., so that they are not able to be used for wide area networks. In the following section we will presented SWOT Analysis for improvement and upgrading of micro-simulation model SFStreetSIModel, version 2.1, as conclusions adopted in accordance with the results of the comparison and taking into account the fact that HUTSIM, NETSIM and FREESIM are commercial micro-simulation models related to the primary city network.

STRENGTHS (S) of SFStreetSIModel, version 2.1

- user interface (easy to use and by a non-technical person
- graphical presentation
- 2D animation
- All pedestrian parameters can be examined and modified
- High level of detail in the modeling process
- modeling of vehicles as rectangles, not points (which is one of the primary recommendations of critics)
- identification of vehicles by type
- following distances has been model:
- vehicle kinematic properties are defined (speed and acceleration) and their status (moving, overtaking or waiting in the queue)
- speed, acceleration and vehicle status and speed and pedestrian status are calculated in each time step

WEAKNESSES (W) of SFStreetSIModel, version 2.1

- No interaction between vehicles and pedestrians at crossings: signalized or non-signalized, with priority for pedestrians or vehicles
- Street restriction
- Limited number of driver profiles
- No ITS functionalities

OPPORTUNITIES (O) of SFStreetSIModel, version 2.1

- pedestrians' appearance, movement and interaction with other modes of transport
- Visual pedestrian evaluation: visualizing speed or acceleration of pedestrians
- modeling of other traffic users (as public transport, bicycles)
- introducing variable response time for drivers by introducing categories of drivers
- vehicle-pedestrian interaction modeling
- modeling of crossections and access points detailed geometry
- signal controllers
- O-D matrices
- 3D animation

Threats (T) of SFStreetSIModel, version 2.1

- Complexity

5. CONCLUSION

Within this work four traffic micro-simulation models are described and compared. A general presentation of their characteristics, performances and modeling principles has been shown, and models and desirable properties of such models have also been given.

As it was recommended [8] further research has been conducted to achieve complete insight in the state of the art in elementary models seed in traffic micro-simulation. A more detailed analysis requires a comparison of simulations based on field data, in order to investigate of the reasons for differences between the individual models (e.g., analysis of car-following model), to investigate the results with changes to the traffic volumes or other feature and for an updated analysis with better calibration data

According to this, iinteresting next steps on the path outlined by this work would be to investigate to that end.

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