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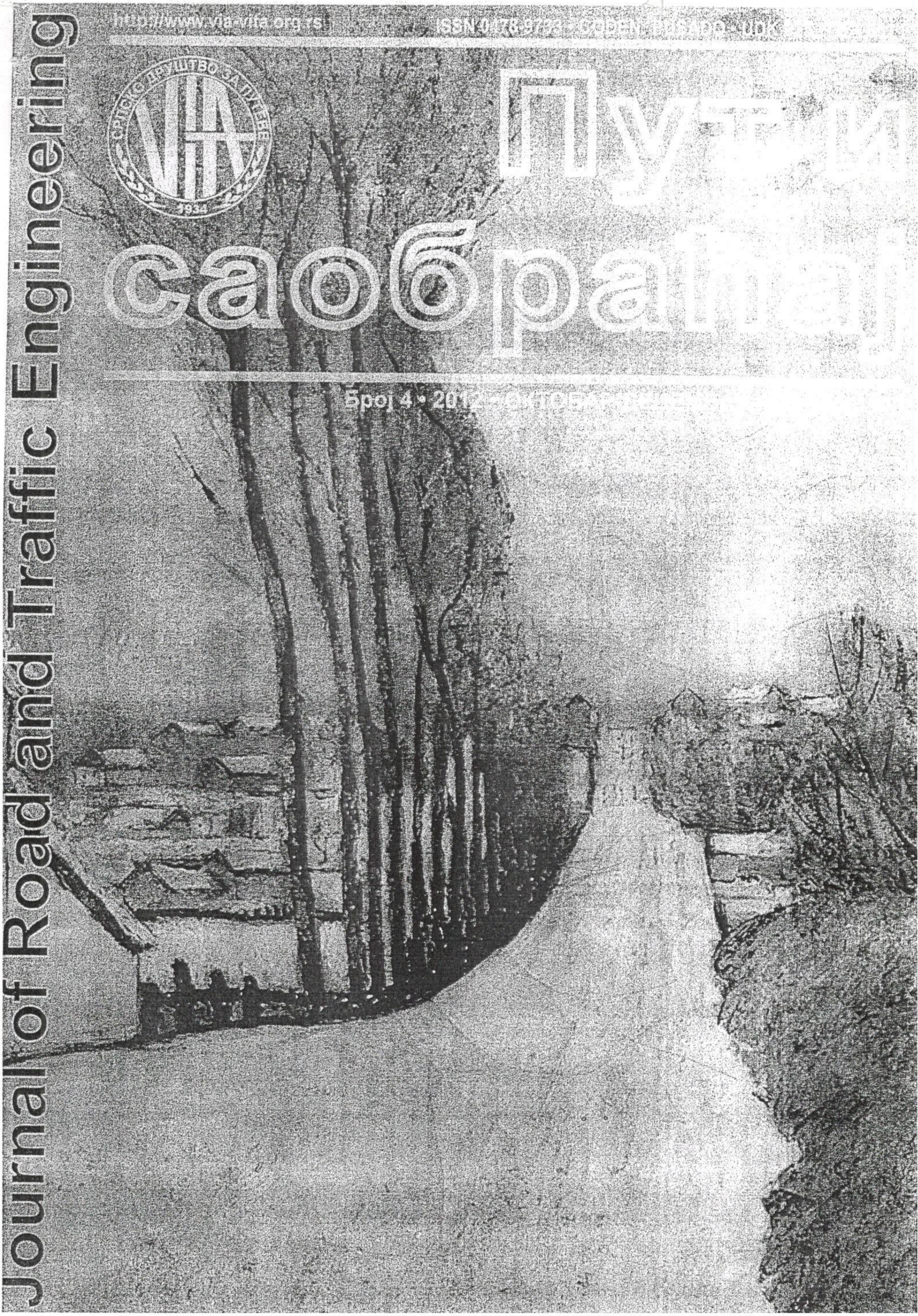

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Број 4 ● Октобар - Децембар 2012 ● Година LVIII

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САДРЖАЈ

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CONTENTS

A COMPARATIVE ANALYSIS OF EDUCATIONALLY DEVELOPED MICROSCOPIC TRAFFIC SIMULATION MODEL -SFStreetSI Model,version 1.1

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Original scientific paper

Abstract: *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 last few years there is a rapid evolution in the sophistication of micro-simulation models and a major expansion of their use in transportation engineering and planning practices. In this paper we presents a comparative analysis between recently developed microscopic simulation model SFSTreetSIModel, version 1.1 for educational purposes and two commercial micro-simulation tools.*

Key words: *Micro-simulation model, Modeling, SO Analysis (S (Strengths), O(Opportunities))*

KOMPARATIVNA ANALIZA MIKROSKOPSKOG SAOBRAĆAJNOG SIMULACIONOG MODELA- SFStreetSI modela, verzija 1.1

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Sažetak: *Mikro-simulacija je modelovanje kretanja pojedinačnih vozila sekund po sekund ili manje od sekunde osnovu radi procene saobraćajanih performansi sistema puta i ulica, JGPP i pešaka. U poslednjih nekoliko godina, prisutna je brz evolucija u sofisticiranosti mikro-simulacionih modela i velike ekspanzije njihove upotrebe u saobraćaju i planiranju. U ovom radu predstavljamo komparativnu analizu između nedavno razvijenog mikro simulacionog modela, SFSTreetSIModel verzija 1.1 za obrazovne svrhe i dve komercijalne mikro-simulacijiona alata.*

Ključne reči: *Mikro-simulacioni model, modelovanje, SO Analiza (S (Strengths), O (Opportunities).*

1. INTRODUCTION

Traffic congestion is a growing problem that is increasingly difficult for states and local authorities to solve. 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. Microscopic and mesoscopic simulation models overcome the inherent limitations of traditional four-step models through their ability to model detailed system operations,[1].

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.

1.1. Object and purpose

The main objective of this research is to compare, describe and evaluate the capabilities of educationally developed micro-simulation model SFSTreetSIModel, version 1.1 and two other commercially available simulation models, in order to obtain directions for its improvement. Here SO (Strengths – Opportunities) analysis will be shown.

2. STATE-OF-THE-ART ON SIMULATION MODELS: AN OVERVIEW

Previous comparisons of micro-simulation programs have been conducted by Brockfeld et. al. (2003)[2], Bloomberg et al. (2003)[3], ITS University of Leeds (1997-2003)[4]. 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 [5].

The classification of traffic simulation tools are generally based on three levels of detail, namely, microscopic, mesoscopic, and macroscopic. Micro-simulation models are essentially research products, seven of them are commercial products (AIMSUN2, FLEXSYT II, FRESIM, INTEGRATION, PARAMICS, TRAFNETSIM and VISSIM) and are continuously in development. Microscopic simulation tools, such as VISSIM, HUTSIM, AIMSUN 2 and other account for the movements of individual vehicles dynamically and stochastically in the network on a second-by-second basis using cellular automata or car-following models. They require detailed geometric, control, and demand data and a large number of calibrated parameters to accurately model driver behavior in the network.

At the other end of the spectrum macroscopic simulation models, such as FREQ and TRANSYT-7F, model the movement of packets of vehicles over a fixed period of time based on the hydrodynamic theory of traffic flow. These models require much less processing power and only a handful of relatively simple parameters in order to work reasonably well. A third approach that is gaining popularity is mesoscopic simulation tools, such as DynaMIT, DynusT, VISTA, and DYNASMART, where a macroscopic traffic flow model is used but vehicles are tracked individually in the network to maintain a higher level of detail [4]. 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 1.1 whose main goal and development is the analysis of traffic flow performances related on the secondary street network, as well as system safety and environmental measures, 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 1.1 but according to their properties, objects and phenomena model show the highest level on suitability for comparative analysis.

3. SFStreetSIModel, version 1.1, HUTSIM AND NETSIM: BASIC FEATURES

Side Friction Street SImulation Model - SFStreetSIModel is an object-oriented, microscopic, discrete model. 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 will hopefully have both scientific and practical contribution for the developing countries, particularly the Western Balkans –WBCs. 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.

HUTSIM is an object-oriented microscopic simulation model that simulates traffic on primary urban network. According to critics, the model offers a flexible and interactive object-oriented, defined and generally detailed vehicle dynamics (whose maximum flow rate reaches 2000 v/h), a high level of detail in modeling and calibration with field data, [6].

NETSIM is a microscopic simulation model, whose main goal is the evaluation of proposed operational solutions on signalized network, thereby evaluating traffic management strategies on the basis on its operational performances, such as: average speed, delays, travel time, fuel consumption and exhaust emissions, [7].

3.1. SFStreetSIModel, version 1.1 vs. HUTSIM vs. NETSIM: 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.

Table 1. Comparison of the basic simulation features

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

Source: Author Ph.D. Dissertation

Table 2. Comparison of the calibration parameters

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

* = 1 second

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

Source: Author Ph.D. Dissertation

Table 3. Comparison in terms of interactions between objects, objects and phenomena modeled

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

* in function of the concentration of the side obstacles and distance to them

** on sidewalk

Source: Author Ph.D. Dissertation

Table 4. Comparison in terms on Comfort and Performance objectives

Objectives	SFStreetSIModel	HUTSIM	NETSIM
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
Safety	• Number of Overtakings	• Headway • Number of accidents • Accidents severity • Interactions with pedestrians	No information
Environment	• Exhaust emissions • Fuel consumption	• Exhaust emissions • Fuel consumptio n	• Exhaust emissions • Fuel consumpti on

Source: Author Ph.D. Dissertation

3.2. SFStreetSIModel, version 1.1: strengths and proposed upgrading possibilities

In the following section we will presented the strengths and the opportunities for improvement and upgrading of micro-simulation model SFStreetSIModel, version 1.1, as conclusions adopted in accordance with the results of the comparison and taking into account the fact that HUTSIM and NETSIM are commercial micro-simulation models related to the primary city network.

Table 5. Strengths of the SFStreetSIModel, version 1.1

STRENGHTS
***EASY TO USE** (and by a non technical person)* • user interface • graphical presentation • 2D animation

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:
  o minimum following safe distance
  o lateral safe distance for overtaking
  o affordable safe overtaking length
  o reasonable safe distance between the overtaking vehicle and vehicle that comes from the opposite direction
  o Additionally safe distance for overtaking
• 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

Source: Author Ph.D. Dissertation

Table 6. SFStreetSIModel, version 1.1, upgrading possibilities

OPPORTUNITIES
• 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

Source: Authors Ph.D. Dissertation

4. CONCLUSION

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

Further research is needed to achieve complete insight in the state of the art in elementary models used 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);

- Investigation of the results changing of the traffic volumes or other features;
- An updated analysis with better calibration data

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

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