Chapter 75
Simulation of Pedestrians and Motorised Traffic:
Existing Research and Future Challenges

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ABSTRACT

The objective of this paper is the analysis of the state of the art in pedestrian simulation models and the identification of key issues for further research, with particular focus on the modelling of pedestrians and motorised traffic. A review and a comparative assessment of pedestrian simulation models are carried out, including macroscopic models, earlier meso- and miscosimulation models (mostly in Cellular Automata) and more recent Multi-Agent simulation models. The reviewed models cover a broad range of research topics: pedestrian flow and level of service, crowd dynamics and evacuations, route choice etc. However, pedestrian movement in urban areas and the interactions between pedestrians and vehicles have received notably less attention. A number of challenges to be addressed in future research are outlined: first, the need to and account for the hierarchical behavioural model of road users (strategic / tactical / operational behaviour); second, the need for appropriate description and parameterization of vehicle and pedestrian networks and their crossing points; third, the need to exploit in the simulation models the results of statistical and probabilistic models, which offer valuable insight in the determinants of pedestrian behaviour. In each case, recent studies towards addressing these challenges are outlined.

BACKGROUND AND OBJECTIVES

The analysis of pedestrian movement in urban areas and their interaction with motorized traffic may allow researchers and traffic managers to understand the behaviour of road users and their response to various strategies or interventions, and eventually to more efficient and targeted planning of pedestrian facilities and traffic control in urban areas, and more accurate estimation of pedestrian safety level. Moreover, in the recent years, pedestrian simulation models are used in

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the framework of wireless vehicular networks, so that pedestrian mobility is taken into account in these networks (Schindelhauer, 2006).

Pedestrian movement is subject to fewer constraints and traffic rules compared to vehicle's movement. The complex and dynamic nature of pedestrians' movement and decision making in urban areas cannot be easily addressed by means of algebraic models, and therefore simulation often appears to be a more appealing modelling approach (Bierlaire et al. 2003; Timmermans et al. 1992). However, simulation models of pedestrian movement have been criticised for lacking the explanatory power required to enable their exploitation for planning and engineering purposes (Papadimitriou et al. 2009). In fact, numerous studies have identified determinants of pedestrian behaviour in terms of road, traffic and human factors; however, these results are seldom exploited in simulation modelling (Ishaque & Noland, 2008) or in wireless mobility models (Maeda et al, 2005).

Within this context, the objective of this paper is the analysis of the state of the art in pedestrian simulation models and the identification of key issues for further research, with particular focus on the modelling of pedestrians and motorised traffic. First, a literature review of existing pedestrian simulation models is carried out. Then, the existing models are assessed and a number of key issues and challenges for improvement of existing models are proposed. In each case, recent studies with recommendations and examples for addressing these challenges are briefly described.

REVIEW OF PEDESTRIAN SIMULATION MODELS

In this section, a review of existing pedestrian simulation models is carried out. The review is an update and improvement of the review presented in Papadimitriou et al. (2009). The pedestrian simulation techniques analysed range from macroscopic to microscopic simulations, of continuous or discrete time, of time- or event-based transition. The related research topics cover traffic flow and level of service, crowd and evacuations, route choice etc.

The review is representative of past and current trends in pedestrian simulation; however it is not exhaustive, especially as regards crowd and evacuation simulation, where a great number of studies are available. Given that the scope of this paper is to focus on simulation studies on vehicle / pedestrian interaction, only the main aspects of crowd simulation are presented. For more comprehensive reviews on this particular topic the reader is referred to Duives et al. (2013).

Moreover, the analysis of pedestrian models intended to be used in wireless mobility models is beyond the scope of this research. These models are a particular family of pedestrian simulation models which should satisfy specific requirements (for details the reader is referred to Balercia et al., 2010, Jardosh et al. 2003). Examples of pedestrian simulation models used in wireless vehicular networks have been presented by Meada et al. (2009), who developed the MobiREAL network simulator to design and evaluate mobile ad hoc network protocols and applications, including a method to create urban pedestrian flows mobility scenarios, which reproduce the walking behavior of pedestrians in urban areas. For a review of pedestrian mobility models used in wireless networks the reader is referred to Schindelhauer (2006) and Maeda (2005) and the references therein.

Macroscopic Models

Macroscopic models are based on traffic flow or queuing theory, or in fluid or continuum mechanics. A comparative assessment of macroscopic pedestrian simulation studies is presented in Table 1.

Hunt and Griffiths (1991) developed macroscopic models for delay acceptance in pedestrians' movement on the basis of decision matrices, in relation to vehicles traffic volumes. Mitchell and Smith (2001) analyzed various topologies