Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 10 (2015) 316 – 326

Transportation Research Procedia

www.elsevier.com/locate/procedia

18th Euro Working Group on Transportation, EWGT 2015, 14-16 July 2015, Delft, The Netherlands

Modeling of shared space with multi-modal traffic using a multi-layer social force approach

F. Pascucci [a,*], N. Rinke [b], C. Schiermeyer [b], B. Friedrich [a], V. Berkhahn [b]

[a] *Technische Universität Braunschweig, Institute for Transportation and Urban Engineering, Hermann-Blenk-Straße 42, 38108 Braunschweig; Germany*

[b] *Leibniz Universität Hannover, Institute of Computer Science in Civil Engineering, Callinstraße 34, 30167 Hannover, Germany*

Abstract

In the field of traffic road design, the shared space approach aims to develop roads from mere traffic infrastructures to public spaces, compelling higher interaction between road users. In this paper we develop the fundamentals for a micro-simulation tool based on the Social Force Model, to represent the motion of road users in such layouts. Working with the observed behavior of users in a pedestrian-friendly intersection in the city of Braunschweig (D), a multi-layer structured model is developed, in which each layer is designated to handle different situations, from free-flow movements to user interactions in crowded situations. Visibility graphs and clothoid estimations are used for designing trajectories of road users for the free flow movement. Furthermore, an enhancement of the classical Social Force Model is provided in order to model long-range collision avoidance behavior. Finally, the enhanced simulation framework is validated by two observed scenarios, which include various conflicts between pedestrians and cars.

Peer-review under responsibility of Delft University of Technology

Keywords: shared space; microscopic simulation; social force model; mixed traffic; trajectories of road users.

1. Introduction

The desire to give streets a social function and to reduce the dominance of vehicles has motivated planners and traffic engineers to consider new design approaches where motorized and non-motorized users share traffic spaces.

* Corresponding author. Tel.: +49-531-39166807; fax: +49-531-39166828.
E-mail address: f.pascucci@tu-braunschweig.de

Peer-review under responsibility of Delft University of Technology
doi:10.1016/j.trpro.2015.09.081

Such a strategy of traffic integration – against the concept of separation – allows increasing the quality of public spaces, promoting social and recreational activities. The permitted passage of motorized vehicles contributes to this purpose by loading and unloading activities of consumer goods and people, and avoids overloading the traffic demand on adjacent networks. Therefore, shared space solutions must be designed carefully for the increased level of interaction between users and consequently the elevated number of conflict situations.

A street layout which implements the cohabitation of different traffic modes is said to have a *shared space design* and consists of a variety of physical features with the aim to reduce demarcation between road users.

Currently the choice of a particular shared space design does not take into account performance indicators like *Level of Service* or safeness. Appropriate micro simulation tools, which can reproduce the operation of shared spaces, are currently lacking. However, such tools would ideally provide precise performance outputs, namely "their efficiency (average road user delays and road capacity), safety (initial time-to-collision) and environmental impacts (emissions based on instantaneous speed and acceleration of vehicles)" (Anvari et al., 2015).

The challenge of our research project MODIS (Multi-modal Intersection Simulation) is to build a micro simulation framework, capable of simulating the movements of road users in shared spaces and calculating performance indicators, in order to evaluate the suitability of a particular solution. In this work the fundamentals of our approach are described starting from the observation of human behavior in a shared space environment. Calibration and validation of the proposed model will be part of future research. After the identification of relevant factors to describe the movement of users (Section 2), a multi-layer micro simulation framework is introduced, paying special attention to the development of Free-Flow Trajectories (FFTs) and the mechanisms of Long-Range Collision Avoidance (LRCA) (Sections 3, 4, 5). The results of the simulation framework are then visually compared to two representative observed situations involving pedestrians and cars (Section 6). Situations involving bicycles have not been analyzed in this work. Concluding remarks and future research directions are then presented (Section 7).

2. Observed behavior of users

For the purpose of modeling the behavior of road users, the motion of users in a crossroads intersection in the university district in Braunschweig (D) is analyzed. Although this intersection has a *Fahrradstrasse* (bicycle priority street) and a classical sidewalk, many shared space operational features are observed, namely the high level of interaction between different traffic modes, the negotiation of priority (including bicycles although they have right of way by law), and the presence of pedestrians standing still and interacting in groups.

Table 1 shows the time period and duration of the on-site survey and the observed volumes of road users, with an indication of the traffic detected in a 15 min. peak period during a lessons break.

Table 1. Time period of the on-site survey and observed volumes of road users. (* relative to the 15-min peak)

Location	Period	Road Users	Observed [n°]	Observed [%]
Intersection Pockelstrasse-Katharinenstrasse-Konstantin Uhde Strasse Braunschweig, Germany	04.06.2014, Wednesday, 12:30 - 13:45 (15 min peak: 13:00 - 13:15)	Pedestrians	1936 (715*)	69.4 (69.5*)
		Cyclists	634 (239*)	22.7 (23.2*)
		Cars, Trucks	220 (75*)	7.9 (7.3*)

The aim is to identify which factors are essential for determining the spatiotemporal evolution of the trajectories of road users. Firstly, the movement of road users differs according to their traffic mode. Vehicles have a high space requirement and limited degree of freedom, and in shared spaces usually behave respectfully towards weak users by decreasing speed and avoiding sudden steering movements as much as possible. On the contrary, pedestrians are able to make sudden changes of direction and speed without difficulty, due to their low walking pace. Finally, cyclists represent a unique hazard for both cars and pedestrians because of their unpredictable behavior resulting from a high degree of freedom combined with a slim outline. Apart from the diversity of traffic users, the streetscape and the level of interaction strongly influence the motion of users.