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MICROSCOPIC AND MACROSCOPIC MODELS FOR COUPLED CAR TRAFFIC AND PEDESTRIAN FLOW

R. BORSCHE * AND A. MEURER *

Abstract. In this paper we study the interaction of pedestrian flow and car traffic. A microscopic model for car traffic on road networks is coupled to microscopic pedestrian dynamics by introducing mutual interaction forces. Based on this description coupling conditions for corresponding macroscopic models as well as for mixed microscopic-macroscopic systems can be motivated. In several numerical examples we study the dynamics of the respective descriptions.

1. Introduction. The mathematical description of traffic flows as well as the dynamics of pedestrians has been source to various different models. For both kind of flows microscopic, kinetic and macroscopic equations have been developed.

In the case of car traffic the most popular model is the macroscopic LWR model [45, 53], which describes the evolution of the density of cars in space and time. Further refined macroscopic models are presented in e.g. [3, 7, 9, 8, 43, 11]. Alternatively the dynamics of each car can be described individually using systems of ordinary differential equations. These microscopic models are often based on the 'follow the leader' principle, i.e. each driver is adapting its speed according to the car in front [2, 33, 50]. In between these types of models there is a kinetic description, i.e. the evolution of the density distribution in time, space and velocity is studied [38, 41, 25, 31, 52, 39, 37]. Some of these models can serve as an intermediate model in order to derive macroscopic equations starting from an microscopic description, as e.g. in [38, 54]. Models combining different aspects of the above ones are considered in [20, 32, 22]. Furthermore such models have been extended to investigate the interaction of drivers with individual properties [46, 56] or different vehicles [51, 26, 61].

Similarly the movement of pedestrians can be described. In the microscopic models the interaction of the individuals can be established by so called social forces accounting for attractive and repulsive behavior [15, 34, 35, 36] or mean field game models [29, 42]. The most prominent macroscopic description is given by the Hughes model [40], where the pedestrians follow the fastest path to their destination. Models focusing more on locally bounded interactions are presented e.g. in [5, 18, 19, 21]. Some of these macroscopic models can be derived from microscopic considerations by introducing appropriate kinetic models [24, 30, 6]. So called multiscale models, which combine properties of both approaches, are studied in [22, 60].

In this paper the coupling of pedestrian and car traffic models is investigated. For the coupling of macroscopic car models at crossroads suitable transfer-conditions are introduced in [17]. A corresponding microscopic behavior at a junction is addressed in section 5.1. The main part of the present paper is addressing the interaction of cars and pedestrians. Starting from the coupling of two microscopic models, by considering the formal mean field limits, coupling conditions for microscopic-macroscopic couplings as well as conditions for a coupling of macroscopic models can be motivated. Such models can be used to describe the interactions of pedestrians and cars at special locations in urban areas, e.g. at cross walks or shared spaces [1, 48].

This paper is organized as follows. In section 2 microscopic models for car traffic and pedestrian flows are introduced. A focus is set on interaction terms, which

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