TEMPLE UNIVERSITY
Department of Mathematics

Applied Mathematics and Scientific Computing Seminar

Room 617 Wachman Hall

Wednesday, 11 September 2019, 4:00 p.m.

Two-Dimensional Microscopic-Macroscopic Models for Traffic Flow on Highways

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Abstract. Prediction and control of traffic have become important aspects of the modern world. In the current mathematical literature, there are different approaches to model traffic flow phenomena using differential equations. Among them, in this talk we focus on microscopic and macroscopic models.

Microscopic scale models describe the trajectory of each individual car by means of a differential-delay equation. Although they provide a very detailed description of the flow, they can be computationally expensive because the large number of equations. Typical example of a microsocpic model is provided by the so-called Follow-The-Leader model (FTL).

Macroscopic scale models, in contrast, provide a large-scale aggregate point of view. They study the evolution of the macroscopic quantities related to traffic flow by means of hyperbolic PDEs inspired by fluid dynamics laws. Macroscopic equations can be treated easily and are suitable for real-time simulations. Among the macroscopic models one typically distinguishes between first-order models (based on scalar hyperbolic equations) and second-order models (comprised of systems of hyperbolic equations). The pioneering work of the first case is the Lighthill-Whitham-Richards model (LWR). While a specific example of the second case is the Aw-Rascle-Zhang model (ARZ).

So far, most of the proposed models are one-dimensional, namely for single lane vehicular traffic dynamic. However, real data are usually recorded on interstate roads with multiple lanes and can be used for deriving or testing models for real road geometry. Further, a simple analysis of safety indicators motivates the study of two-dimensional models, since there are traffic regimes in which lane changing maneuvers have a significant impact on surrounding traffic. In this talk, we discuss two-dimensional extensions of classical microscopic and macroscopic models, which treat lanes as continuum and postulate a dynamic orthogonal to the driving direction. In the first-order model, the precise form of the dynamic is established through comparisons with fundamental diagrams obtained from trajectory data recorded on a road section of the A3 German highway near Aschaffenburg. Thus, the experimental measurements allow us to derive a model being able to take into account the realistic dynamic on the real road geometry without prescribing heuristically the behavior of the flow of vehicles. Comparison with prediction of one-dimensional LWR model shows the improvement in performance of the novel model. Then, we extend the novel two-dimensional first-order equation by considering a two-dimensional ARZ-type model derived by a two-dimensional FTL model via formal macroscopic limit.