Mini-course

Traffic models and autonomous driving

Collective dynamics and stability analysis

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Online with Zoom[1] — 6 Tuesdays from November, 10th to December, 15th, 2020, 10:00–12:00

Abstract The topic of the mini-course is about road traffic flow models, especially microscopic models, and autonomous driving. It is intended to doctoral students, post-docs and researchers interested by road traffic and pedestrian dynamics, and the thematic of connected and autonomous vehicle. An introduction to traffic flow theory presents the main variables, models and empirical characteristics. The traffic is introduced as a complex dynamical system, describing many collective self-organized emergent phenomena, typically stop-and-go waves (phantom jam) or lane formation. The stability analysis allows establishing a relationship between the microscopic parameters of microscopic models and the macroscopic homogenization properties of a flow. Traffic flows tend to describe irregular streaming with stop-and-go waves propagating backward. The homogenization of traffic flows is one of the main objectives of the driving automation, for evident safety and comfort reasons, and also environmental ones. Many factors may perturb or even break the stability of homogeneous streaming that we propose to review. Examples are delayed and latency time in the dynamics, stochastic noise and heterogeneity of the driving behavior, or limited kinematic capacities. The challenge for automation of the vehicle speed consists of elaborating feasible, comfortable and robust acceleration model describing macroscopically stable homogeneous streaming. Several classical models borrowed from the literature will be applied and numerically tested with the multi-agent simulation freeware NetLogo. The participants will be trained to use NetLogo and to develop and simulate different models for the automation of the speed.

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Bibliography

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- A. Tordeux, M. Roussignol, S. Lassarre. Linear stability analysis of first-order delayed car-following models on a ring. *Phys. Rev. E* 86:036207, 2012.
- R.E. Wilson, J.A. Ward. Car-following models: fifty years of linear stability analysis – A mathematical perspective. *Transportation Planning and Technology*, 34(1):3–18, 2011.
- M. Treiber, A. Kesting. *Traffic flow dynamics*. Springer, 2013.

Some links

- Wikibooks: Fundamentals of Transportation/Traffic Flow
- Tutorial *A Mathematical Introduction to Traffic Flow Theory* by B. Seibold, UCLA, helper.ipam.ucla.edu/ publications /tratut/tratut_12985.pdf
- NetLogo : ccl.northwestern.edu/netlogo/ (online simulation, download)
- Phantom jam and ACC systems : youtube.com/watch?v=2mBjYZTeaTc
- Utopies for autonomous driving : youtube.com/watch?v=iHzzSao6ypE youtube.com/watch?v=4SmJP8TdWTU

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