Traffic models in large-scale urban networks

Supervisors: **Carlos Canudas-de-Wit** (DR-CNRS, supervisor), Maria Laura Delle Monache (CR-Inria, co-supervisor)
Application type: PostDoc. **Gross salary:** 2617 Euros/month (CNRS PostDoc official salaries).
Start: anytime. **Duration**: 12 months, renewable. **Employer:** CNRS. **Location**: Grenoble, France
Applications: Information at : http://scale-freeback.eu/openings/
Requested Background: Applied mathematics, data science, traffic modeling, control science
Where to apply: https://emploi.cnrs.fr/Offres/CDD/UMR5216-ALLBEL-011/Default.aspx?lang=EN

Context. **Scale-FreeBack** is an ERC Advanced Grant awarded to Carlos Canudas-de-Wit, Director of Research at the National Center for Scientific Research (CNRS), for the period Sep. 2016-2021. The ERC is hosted by the CNRS. The project will be conducted within the NeCS group (a joint CNRS (GIPSA-Lab)-INRIA team), at Grenoble France. Scale-FreeBack is a project with the overall aim of developing *holistic scale-free control methods of controlling complex network systems in the widest sense, and to set the foundations for a new control theory dealing with complex physical networks with an arbitrary size*, see scale-freeback.eu

Topic description. This research proposal deals with the problem of modeling and validating urban traffic network at an aggregated level. In this framework a field of research concentrates on two dimensional PDE models while another group of works concentrates on the notion of Macroscopic Fundamental Diagram (MFD). Starting with some empirical observation of traffic in a city, [3] show that it is possible to exhibit a relation between the average density and the average flow over a whole network. This result enables the introduction of accumulation models —also called reservoir models — which consist of representing the traffic state of a network with a single scalar field variable representing the total number of vehicles in the network. These models are practical because they are understandable, with few parameters to tune and a low computational cost. However, they contain little information about the traffic states. For example, they are not able to describe precisely where vehicles are located over the reservoir. This problem was later on addressed in some papers in which the authors separated different areas of the city with different reservoirs, see for example [4]. Other models show that traffic in urban areas can be modeled with two-dimensional continuous and dynamic models. These models represent the traffic density as a variable over a 2D-plane. Such models are based on a two-dimensional conservation law and a review of some of these model have been done by [5] . As 2D models are recent, there is little validation or calibration of these models. A first challenge in testing 2D models is to obtain a two-dimensional density function from real traffic data. In particular, the reconstruction of a density in the 2D-plane from vehicle data on the road network needs to be defined properly.

In the project we developed 2D-LWR model [1],[2] (which includes 2D wave propagations. This model can be seen as a natural extension to 2D of the well-known CTM. This was the first 2D model with a geometry-dependent flux where the magnitude depends on the density and the direction depends on space. However, at the current stage, the model is able to represent only monodirectional flow. The main goal of this post-doc is to extend this model to multidirectional flow (probably using a multi-layer approach) and to validate the model using synthetic and real data. Several specific task will be expected:

- Extend our previous model to a 2-D *multilayer* PDE model for a large-scale urban traffic systems based on the 2D-LWR model ideas
- Starting from real data, recover the function in the PDE that models the flux function and the interaction between cars using inverse problems.
- Validate the model using a microscopic simulator
- Perform experiments in our micro-simulator to verify the aggregation process, and the validity of the detailed model.

Field tests and other realistic simulations to validate the theory will be performed using the equipment available at the Grenoble Traffic Lab center (see GTL), that is currently being extended at the level of city-center of Grenoble (GTL-Ville project) where we are collecting traffic related data and constructing a real-time data-collection systems. The algorithms developed in this work, will be integrated into the GTL-Ville project. Experiments that cannot be realized in vivo, will be tested on a microscopic traffic simulator replicating the full complexity of the Grenoble urban network.

[1] A simple example of two dimensional model for traffic: discussion about assumptions and numerical methods

Stéphane Mollier, Maria Laura Delle Monache, Carlos Canudas de Wit
TRB 2018 - Transportation Research Board 97th Annual Meeting, Jan 2018, Washington, D.C., United States. pp.1-20
[2] Two-dimensional macroscopic models for large scale traffic networks
Stéphane Mollier, Maria Laura Delle Monache, Carlos Canudas de Wit, Benjamin Seibold
Transportation Research – Part B, 122, (2019), 309-326.
[3] Existence of urban-scale macroscopic fundamental diagram
N. Geroliminis, C. F. Daganzo, Transport. Research Part B, 42(9) (2008), 759-770
[4] Macroscopic traffic dynamics with heterogeneous route patterns
L. Leclercq, C. Parzani, V. L. Knoop, J. Amourette, S. P. Hoogendoorn, Transp. Res. Procedia, 7 (2015), 631-650
[5] Dynamic traffic assignment using the macroscopic fundamental diagram: a review of vehicular and pedestrian flow models
R. Aghamohammadi, J. Laval, Transp. Res. Part B, online (2019)