Traffic control in large-scale urban networks

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Application type: PhD. **Gross salary:** 1757 Euros/month (CNRS PhD official salaries).
Start: anytime from Sep. 2018. **Duration**: 36 months. **Employer:** CNRS. **Location**: Grenoble, France
Applications: http://scale-freeback.eu/openings/
Requested Background: Control systems, applied mathematics, estimation theory

   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*.

   Topic description. This research proposal deals with the problem of controlling urban traffic network at an aggregated level. In fact, the control of "*one-dimensional networks*" (i.e. freeways) has been extensively studied using several approaches like: ramp metering, variable speed limits, rerouting, etc. However, urban traffic control *on networks* involves different techniques, and calls for different formulations. The main tools used to control urban traffic are traffic lights. Several approaches were developed in the past. Split cycle and offset optimization (SCOOT) and Sydney coordinated adaptive traffic system (SCATS) work well only when the traffic conditions are below saturation. Others like PRODYN, real-time hierarchical optimized distributed and effective system (RHODES) and optimization policies for adaptive control (OPAC) are based on optimization algorithms but show numerical limitations when deployed in real time, and can therefore be used only at a few intersections. Model-based control optimization methods are *centralized* and hence require significant communication infrastructure, while the Max-Pressure (MP) control approach is *a local feedback requiring only information from adjacent links*.

   The aim of the above-mentioned studies was to control vehicle flows at each individual node. An alternative approach, which follows the ideas of the Scale-FreeBack project and is the objective of this thesis, consists in controlling only the inflows/outflows at the perimeter of some specific areas. This "gating control strategy" was studied previously using ramp metering-like methods borrowed from the one-dimensional networks, but fundamental issues focusing on stability, scalability, controllability/observability and time-varying controlled areas were not considered. To some extent, no efficient methods of traffic light control at the large-scale network level and meeting the associated complexity issues have yet been found. This PhD thesis proposal aims at going beyond the present state of the art by introducing an innovative scalable model-based control approach, based our recent developed 2D-LWR model [1] (which includes 2D wave propagations) in the team. This model can be seen as a natural extension to 2D of the well-known CTM. Several specific task will be expected:

- Study the controllability/observability of the 2D-CTM model
- Partition the network in zones which are controllable
- Identify (among all possible traffic light) control inputs those which are the most representative in our context.
- Design boundary control laws to improve the relevant traffic metrics
- Validate the concept using a microscopic simulator.

   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
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