
Ph.D. research topic

- Title of the proposed topic: AI for road traffic modeling and management
- PhD
- Research axis of the 3iA: AI for intelligent and secure territories
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- Potential co-supervisor (name, affiliation): Mickaël Binois, Inria
- The laboratory and/or research group: ACUMES project-team at Inria Sophia Antipolis – Méditerranée

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- The description of the topic:

At a macroscopic scale, traffic is usually represented as a fluid flowing on the road network. In order to characterize the evolution of the system, we define aggregated quantities such as the flow or density of vehicles. The challenge is to be able to understand, reproduce and anticipate the evolution of density and flux in space and time, relying both on this mathematical modeling and on traffic data.

There exists nowadays a variety of road traffic data sources (magnetic loop detectors, video cameras, floating car data, Bluetooth, etc), which can be used for model calibration. That is, finding plausible values for parameters (possibly non physical) of the traffic model. In particular, the heterogeneity of traffic conditions in congested regimes makes it hard to obtain a good matching between simulations and reality, thus preventing from obtaining reliable traffic state predictions beyond short time horizons (15-30 min). Indeed, traffic models are usually set on a unique choice of the fundamental diagram (flux-density relation), independently of the time of the day and the day of the week. Yet, model parameters may be time dependent, as some traffic conditions and driver behavior may be correlated to specific time ranges. Besides, data analysis techniques may help in opening new perspectives in the interpretation of data and the modeling of road traffic.

This project aims at analyzing information derived from traffic data using innovative machine learning methods and at exploiting them within deterministic PDE models. The targeted statistical methods rely in particular on model-based functional co-clustering and Gaussian process modeling. The traffic data will be seen in this context as time functions and the statistical methods will identify groups of homogeneous loops (road network types) as well as groups of time moments (days of the week). This analysis could allow us to refine the mathematical models developed by ACUMES project-team by identifying different standard days or a spatial typology of networks. The analysis would also allow us to calibrate certain fundamental parameters of our models.

This coupling of probabilistic methods with physically grounded mathematical models is also expected to ensure traffic predictions remain plausible in regimes with no or corrupted data.

Ultimately, both aspects are necessary to perform simulations and enable safe control at a larger scale.

ACUMES Project-Team has an established experience in (macroscopic) traffic flow models, and disposes of a large set of data coming from 135 loop detectors placed on the freeways in the North of Marseille (A7, A51, A50 and A55). The data-set was provided by the Direction Interdépartementale des Routes Méditerranée (DIRMED) and covers 3 months, from September 1st to November 30th, 2015. In particular, calibration results will contribute to the development of TramOpt, a software platform for traffic simulation and control developed by the team.

Further actions to recover new data will be conducted during the project.