Numerical analysis of dynamical flows in networks.

6 months internship. Postgraduate Master degree/ Engineering school.
Santiago de Chile. Starting date between January 2015 up to July 2015

Context The goal of this work is to better understand the dynamics of flows in networks that can model urban traffic, crowd motion in emergency evacuation or internet communication protocol. Most of the time, the dynamics is characterized by a lack of coordination between agents and have to be considered from a game theoretic point of view. In a Nash equilibrium, flow particles (infinitesimal flow units) selfishly choose an origin-destination path of minimum latency. In very recent works, a queuing model together with maximum capacities and time delays on each arcs has been studied in [3, 2, 1]. In particular, some constructive results are given for flows over time when the flow input to the network in piecewise constant. For the more general case ($\mathcal{L}^p([0,T],I\!R), p \geq 1$ input), only an abstract existence result has been given in [1].

Objectives The objectives of the internship aim at proposing a constructive method for the solution of the flows over time for general flow input. The goal is twofold: a) obtaining a existence theorem for the flow and b) a numerical scheme as efficient as possible for the numerical computation of flows in large networks. More precisely, according to the main interest of the applicant, the following items might be studied:

- Time–discretization of the problem of flows over time. This discretization has to take into account the nonsmooth character of the solution (discontinuous ordinary differential equations, differential variational inequalities)
- Convergence of the scheme and existence of solutions. The goal is to use compactness theorems to prove the existence of solutions using the time–discretization.
- Implementation and algorithmic aspects. Up to now, the computation for a constant flow input requires to solve a problem with an exponential time algorithm (each iteration is a sparsest cut problem in a directed graph). For each time–step of the time–integration method, is it possible to improve the algorithm or to obtain get a polynomial time algorithm ?

Naturally, the objective of the internship is not to tackle all these questions. With the help of researchers of the university of Chile (R. Cominetti and A. Daniilidis), the intern will focus one of this issue.

Work environment Inria Chile is a recently-established foundation in Santiago de Chile, set up by Inria ("Institut National de Recherche en Informatique et en Automatique"), a French public institution devoted to Research and Development of future digital technologies within the fields of computer sciences and applied mathematics. Inria Chile seeks to be, within its areas of expertise, a strategic innovation partner for the Chilean industry and society. We rely on recent discoveries made either by our university partners in Chile or by our researchers in France.

Required skills

- Applied maths (Functional analysis, differential inclusion, operation research, optimization)
- Numerical modeling and scientific computing (good skills in software development is important).
- English. Spanish would definitively be a plus.

Practical aspects

- Location: INRIA Chile. Santiago de Chile [1]
- Duration : 6 months. Pay : around 800 000 pesos + flight tickets
- Contact : Vincent Acary. Research fellow INRIA Chile, `vincent.acary@inria.cl` [2].

This work could result in a grant for a PhD thesis. This subject and its application to the emergency exit plan when a earthquake or tsunami event arises, have proven to be of utmost importance in Chile.

References

[1] R. Cominetti, J.R. Correa, and O. Larré. Dynamic equilibria in fluid queueing networks. *submitted*, 2014.

[2] R. Koch. *Routing Games over Time*. PhD thesis, Technischen Universitaï Berlin, 2012.

[3] R. Koch and M. Skutella. Nash equilibria and the price of anarchy for flows over time. *Theory Comput. Syst.*, 49(1):71–97, 2011.

[1] http://www.inria.cl
[2] http://bipop.inrialpes.fr/people/acary