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ANALYSIS AND CONTROL ON NETWORKS: TRENDS AND PERSPECTIVES

In the last twentyfive years, there has been a dramatic increase of the number of works devoted to the analysis of flows dynamics on networks based on hyperbolic partial differential equations (PDEs), which appear versatile tools for the development of control strategies and real-time computational methods more efficient and less expensive than the ones derived by microscopic and discrete models, in particular for large-scale systems.

The vitality of the field is also motivated by a wide range of strategic applications in modern society: from vehicular traffic and urban design to gas and water management, to biological and medical structures, to communication and data systems, to supply-chain planning, or also to social consensus patterns and cultural connections. In order to successfully address the challenging problems arising in these applications, the available analytic techniques of the theory of one-dimensional PDEs must be adapted to tackle the complex features of the specific models taken in consideration and combined with other tools and approaches developed within the control theoretic community. At the same time, a key role in this effort is played by the introduction and analysis of advanced numerical methods that allow to effectively test the theoretic findings in concrete problems.

The workshop *"Analysis and Control on Networks: trends and perspectives"* that took place in Padova on March 9-11, 2016, brought together some of the leading experts in the fields of hyperbolic conservation laws and of control and optimization of PDEs, that have achieved most influential recent advances in these areas. The present and the forthcoming *Networks and Heterogeneous Media* Issue collect some significative recent results related to the research area of continuous flows on network structures, most of which were discussed in the aforementioned workshop, without the pretence of covering all themes of this broad field. In particular, this volume focuses on the following topics:

- Theoretical results on junctions with buffers, phase-transition models, PDE-ODE models, mainly motivated by traffic-flow problems.
- Analysis of measure-based models for networks and for multi-agent systems.
- Control methods for network flows via semigroup approach and investigation of numeric schemes for animal group-size evolution models.

More precisely, Bressan and Nordli introduce a Riemann solver at a junction that determines the limiting solution obtained in presence of a buffer when the buffer's capacity vanishes. Remarkably, the resulting solution depends Lipschitz continuously on the turning preference and relative priority parameters. A Riemann solver is a rule that specifies how to construct the solution at an intersection when the initial traffic-flow density is constant on each incoming and outgoing roads.

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Because of the finite speed of propagation, once a Riemann Solver at a junction is prescribed, the Cauchy problem on a network can be uniquely solved under suitable assumptions.

Mohamed and Rosini investigate a phase-transition model (describing the free and congested phases) for vehicular traffic with local point constraints that take into account the presence of obstacles hindering the flow of vehicles. They introduce two constrained Riemann solvers for this problem and analyze their properties. Instead, the existence of solutions to the initial-boundary value problem for a similar phase-transition model, without constraints, is established in the paper of Marcellini via a front-tracking algorithm.

The phenomena of moving bottlenecks in traffic flow motivates the analysis of conservation laws with moving constraints as in the paper of Delle Monache and Goatin where a first important step is provided toward the establishing of a well-posedness theory for a strongly coupled PDE-ODE system of this form.

Camilli, De Maio and Tosin analyze the existence of measure-valued solutions to a linear transport equation on a network by first considering a local boundary value problem on each single arc of the network, and then gluing together all solutions according with appropriate distribution rules at the vertices. The evolution of measures on network structures allows a better description, in a multi scale micro-macro perspective, of phenomena such as aggregation, congestion and pattern formation arising for instance in crowd motion modelling.

A time-optimal control problems for positive measures driven by a continuity equation is the object of investigation of the work of Cavagnari, Marigonda and Piccoli. Here the problem is motivated by applications in multi-agents systems or in pedestrian dynamics, for example in the evacuation problem where the goal is to drive a crowd of people outside an environment space in a minimum amount of time. The analysis carried out in this paper is performed in a non-interacting setting providing a first step toward further investigations of interacting particle systems.

K.-J. Engel and Kramar Fijavž consider a control problem for a transport process along a network governed by linear operators, assuming that the controls act at the vertices. They employ an abstract semigroup approach to characterize the reachable states in finite time via positive valued controls.

The work of Degond and M. Engel deals with coagulation-fragmentation integral equations that model rates of merging and splitting of animal group sizes. In particular they perform a numerical investigation of the resulting continuous and discrete equilibrium distributions using three different schemes and analyze the convergence in time to such equilibria.

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