ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

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➢ **THURSDAY 27 APRIL 2017 - ROOM CM 1 221 - 14:15**

Dr Enrico FACCA (University of Padua, IT) will present a seminar entitled:

« Biologically inspired formulation of optimal transportation problems. An unexpected branching source»

Abstract:

We have recently developed an approach, based on an extension of a model proposed by Tero et al (2007), for the simulation of the dynamics of a slime mold (Physarum Polycephalum). We conjecture that the long-time solution of the proposed model approaches the solution of the PDE base Monge-Kantorovich Optimal Transport equations. This new OT formulation assumes that the potential and the diffusion coefficient (the latter yielding the transportation plan) are time dependent and satisfy an elliptic PDE. The classical constraint on the norm of the gradient is then replaced by an ODE describing transient dynamics of the diffusion coefficient. Analytical results in the case of the Monge-Kantorovich problem, although yet largely incomplete, suggest that indeed the conjecture is true. This is supported by several numerical experiments performed on a number of published test cases. One of the most important advantages of the proposed formulation is that its numerical solution is very efficient and well-defined using simple discretization schemes. Moreover, this dynamical extension allows the reconstruction of the time-history of the process, thus enlarging the range of application of the proposed OT model to a large set of physical and biological processes. Simple modifications of the proposed model yield dynamic versions of the branched and congested transport problems.

We shall discuss our numerical approaches, which are based on either a standard linear (P1) Galerkin method, or a pseudspectral scheme combined with a P0 approximation of the diffusion coefficient, for the discretization of the elliptic PDE and Euler time stepping and Picard iteration to

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solve the resulting nonlinear differential-algebraic equation. Preliminary numerical simulations are used to show that the proposed formulation is efficient in finding solutions also of congested and branched transport problems. Although limitations arise when trying to solve highly discontinuous problems, we present experimental convergence results showing robustness of the scheme for a wide range of sample problems. Finally, we will examine models and related numerical results of diverse applications ranging from slime-mold dynamics to geomorphological problems, and discuss current and future progress.

Lausanne, 13 April 2017/FN/rb