Ph.D. Defense

by

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Large Scale Stochastic Control: Algorithms, Optimality and Stability

Summary:
Optimal control of large-scale multi-agent networked systems which describe social networks, macro-economies, traffic and robot swarms is a topic of interest in engineering, biophysics and economics. A central issue is constructing scalable control-theoretic frameworks when the number of agents is infinite.

In this work, we exploit PDE representations of the optimality laws in order to provide a tractable approach to ensemble (open loop) and closed loop control of such systems. A centralized open loop optimal control problem of an ensemble of agents driven by jump noise is solved by a sampling algorithm based on the infinite dimensional minimum principle to solve it. The relationship between the infinite dimensional minimum principle and dynamic programming principles is established for this problem.

Mean field game (MFG) models expressed as PDE systems are used to describe emergent phenomenon in decentralized feedback optimal control models of a continuum of interacting agents with stochastic dynamics. However, stability analysis of MFG models remains a challenging problem, since they exhibit non-unique solutions in the absence of a monotonicity assumption on the cost function. This thesis addresses the key issue of stability and control design in MFGs. Specifically, we present detailed results on models for flocking and population evolution.

An interesting connection between MFG models and the imaginary-time Schrödinger equation is used to obtain explicit stability constraints on the control design in the case of non-interacting agents. Compared to prior works on this topic which apply only to agents obeying very simple integrator dynamics, we treat nonlinear agent dynamics and also provide analytical design constraints.

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