Optimization, Mean Field Games and Applications

Workshop in Honor of the 70th Birthday of Professor Roland P. Malhamé

July 27, 2025

Room 6214, André-Aisenstadt Building, Université de Montréal Campus
2920 chemin de la Tour Montréal QC H3T 1J4 Canada

Program Schedule

- **Date:** July 27, 2025
- **Time:** 8:25 AM – 5:15 PM
- **Location:** Room 6214, André-Aisenstadt Building, Université de Montréal, 2920 chemin de la Tour Montréal
- **Talk Duration:** 25min talk + 5min question each
- **Coffee Breaks:** 10:15–10:45 AM and 3:15–3:45 PM
- **Lunch:** 12:15–1:45 PM
- **Dinner:** 6:30 pm, July 27, 2025 @ La Maison Grecque, 450 Av. Duluth E., Montreal, QC, H2L 1A5

Time	Event / Speaker (Affiliation)
Opening	
8:25–8:30 AM	Opening Remarks
Session 1: 8:30–10:15 AM	
8:30–9:00 AM	Peter E. Caines (McGill University) with Rinel Foguen-Tchuendom
9:00–9:30 AM	Michele Breton (HEC Montréal)
9:30–10:00 AM	Behrouz Touri (University of Illinois Urbana-Champaign)
10:15–10:45 AM	**Coffee Break**
Session 2: 10:45 AM – 12:15 PM	
10:45–11:15 AM	Georges Zaccour (HEC Montréal)
11:15–11:45 AM	Tamer Başar (University of Illinois Urbana-Champaign)
11:45–12:15 PM	Dena Firoozi (University of Toronto)
12:15–1:45 PM	**Lunch Break**
Session 3: 1:45–3:15 PM	
1:45–2:15 PM	Ravi Mazumdar (University of Waterloo)
2:15–2:45 PM	Huyên Pham (École Polytechnique, Paris)
2:45–3:15 PM	Tryphon T. Georgiou (UC Irvine)
3:15–3:45 PM	**Coffee Break**
Session 4: 3:45–5:15 PM	
3:45–4:15 PM	Prashant G. Mehta (University of Illinois Urbana-Champaign)
4:15–4:45 PM	Gökce Dayanikli (University of Illinois Urbana-Champaign)
4:45–5:15 PM	Mathieu Lauriere (NYU Shanghai)

Organizing Committee:
Peter E. Caines (McGill), Shuang Gao (PoltMtl), Minyi Huang (Carleton), Georges Zaccour (HEC Montréal)

Website: https://people.math.carleton.ca/%7Emhuang/WorkshopJul25/Omfg25.html

Detailed information of talks: speakers listed alphabetically

- **Title**: Networked Games with Delayed Coupling in the High Population Regime

  Speaker: Tamer Başar, University of Illinois Urbana-Champaign

  Abstract: The talk will address non-cooperative (Nash) equilibria for a class of stochastic nonzero-sum discrete-time dynamic games with networked players, where each player has its own state dynamics, with the states of other players entering with some time delay. Such delayed coupling makes this a nonstandard class of games where the existing theory with a finite number of players does not apply or any theory that can be developed (which will be discussed) would not be scalable in the length of the horizon (requiring infinite memory) as well as in the number of players. One resolution would be to go to the infinite population limit, where the talk will introduce a general methodology within the mean-field framework, leading to a mean-field equilibrium, which will then be used to obtain an approximate Nash equilibrium when there is a finite number of players. The approximate Nash equilibrium policies of the players turn out to be in the form of current local state feedback and some mean-field term generated by high-order dynamics.

- **Title**: Ranking Quantilized Mean-Field Games with an Application to Early-Stage Venture Investments

  Speaker: Michèle Breton, HEC Montréal (with Rinel Foguen Tchuendom, Dena Firoozi)

  Abstract: Quantilized mean-field game models involve quantiles of the population's distribution. We study a class of such games with a capacity for ranking games, where the performance of each agent is evaluated based on its terminal state relative to the population's -quantile value, . This evaluation criterion is designed to select the top performing agents. We provide two formulations for this competition: a target-based formulation and a threshold-based formulation. In the former and latter formulations, to satisfy the selection condition, each agent aims for its terminal state to be *exactly* equal and *at least* equal to the population's -quantile value, respectively.

  For the target-based formulation, we obtain an analytic solution and demonstrate the ε-Nash property for the asymptotic best-response strategies in the N-player game. For the threshold-based formulation, we obtain a semi-explicit solution and numerically solve the resulting quantilized mean-field consistency condition.

  Subsequently, we propose a new application in the context of early-stage venture investments, where a venture capital firm financially supports a group of start-up companies engaged in a competition over a finite time horizon, with the goal of selecting a percentage of top-ranking ones to receive the next round of funding at the end of the time horizon. We present the results and interpretations of numerical experiments for both formulations discussed in this context and show that the target-based formulation provides a very good approximation for the threshold-based formulation.

- **Title**: Mean Field Game Theory Meets Agent-Based Complexity Economincs

  Speaker: Peter E. Caines, McGill University (with Rinel Foguen-Tchuendom)

  Abstract: Complexity Economics (J. D. Farmer, "Making Sense of Chaos," Penguin Books, 2024) is characterized by three key features: (i) economic agents are modelled behaviourally in dynamical states rather than as "rational optimizers" with full or limited information, in a market equilibrium ; (ii) computational experiments are conducted employing large scale individual behavioural agent models for economic, financial, epidemiological and related systems, and (iii) the inherent nonlinearity of such models may conceal chaotic dynamics whereby the resulting strange attractors generate endogenous stochastic behaviour; this is used to explain, for instance, financial bubbles without use of classical exogenous shocks and noise processes. In this exploratory talk, features (i) and (ii) will be shown to permit a Mean Field Systems formulation which dramatically simplifies the computational scenarios and allows the description of analytically relevant equilibrium quantities; in particular, the mass market asset equilibrium price in the case of a financial example (M.P. Scholl, A.Calinescu and J.D. Farmer, PNAS,118, (26), 2021) will be described in terms of the mean field state distributions of a small number of generic behavioural agent types.

- **Title**: Cooperation, Competition, and Common Pool Resources in Mean Field Games

  Speaker: Gökce Dayanikli, University of Illinois Urbana-Champaign

  Abstract: The tragedy of the commons (TOTC, introduced by Hardin, 1968) states that the individual incentives will result in overusing common pool resources (CPRs) which in turn may have detrimental future

consequences that affect everyone involved negatively. However, in many real-life situations this does not happen and researchers such as the Nobel laureate Elinor Ostrom suggested mutual restraint by individuals can be the preventing factor. In mean field games (MFGs), since individuals are insignificant and fully non-cooperative, the TOTC is inevitable. This shows that MFG models should incorporate a mixture of selfishness and altruism to capture real-life situations that include CPRs. Motivated by this, we will discuss different equilibrium notions to capture the mixture of cooperative and non-cooperative behavior in the population. First, we will introduce mixed individual MFGs and mixed population MFGs where we also discuss the modeling of CPRs. The former captures altruistic tendencies at the individual level and the latter models a population that is a mixture of fully cooperative and non-cooperative individuals. For both cases, we will briefly discuss definitions and characterization of equilibrium with the forward backward stochastic differential equations. Later, we will discuss a real-life inspired example of fishers where the fish stock is the CPR. We will analyze the existence and uniqueness results and discuss the experimental results.

- **Title**: Coupled Semilinear Stochastic Evolution Equations and LQ Mean Field Games in Hilbert Spaces: Cases with and without Common Noise

  Speaker: Dena Firoozi, University of Toronto

  Abstract: We first study the well-posedness of a system of N coupled semilinear stochastic evolution equations establishing the foundation of MFGs in Hilbert spaces. We then specialize to N-player LQ games and study the asymptotic behavior as the number of agents, N, approaches infinity. We develop an infinite-dimensional variant of the Nash Certainty Equivalence principle and characterize a unique Nash equilibrium for the limiting MFG. We demonstrate that the resulting limiting best-response strategies form an ϵ-Nash equilibrium for the N-player game in Hilbert spaces. We then extend these results by including an infinite-dimensional common noise. In the presence of common noise, the mean-field consistency condition is expressed as forward-backward stochastic evolution equations, while in its absence, it is expressed as forward-backward deterministic evolution equations in Hilbert spaces. We establish the solvability of these stochastic equations and the ϵ-Nash property for the equilibrium strategy in this scenario.

- **Title**: On the border between Classical and Quantum via continuous measurements

  Speaker: Tryphon T. Georgiou, UC Irvine

  Abstract: In recent years the theory and technology of quantum measurement are undergoing rapid development, fueled by both, technological advances, as well as a pressing need for a new type of computational model. Our focus is on the dichotomy between classical and quantum in the probabilistic description of more than one observables. We will provide a novel interpretation of the Husimi probability function as the conditional density of continuously monitoring a stream of persistent outcomes of quantum measurement. This new formulation extends naturally to an arbitrary collection of observables without reference to coherent states, as a limit description of a quantum system based on information being siphoned continuously and indefinitely. The new description recovers the Husimi distribution for i) pairs of conjugate variables, ii) spin-half particles when monitoring the three Pauli matrices, as well as iii) recovers Born's rule when monitoring commuting quantum observables. The proposed paradigm generalizes the Husimi function and generates positive representations of quantum states as conditional densities, for both finite and infinite time experiments, and as expectations of a fundamental operator, the Gaussian semigroup on the Hilbert space of the quantum states.

  The presentation is on joint work with Ralph Sabbagh and Olga Movilla Miangolarra, and is based on https://arxiv.org/abs/2505.00245

  Online: ZOOM Meeting ID: 934 6308 4287 Passcode: 047410

- **Title**: Probabilistic Analysis of Graphon Mean Field Control

  Speaker: Mathieu Lauriere, NYU Shanghai

  Abstract: Motivated by recent interest in graphon mean field games and their applications, this paper provides a comprehensive probabilistic analysis of graphon mean field control (GMFC) problems, where the controlled dynamics are governed by a graphon mean field stochastic differential equation with heterogeneous mean field interactions. We formulate the GMFC problem with general graphon mean field dependence and establish the existence and uniqueness of the associated graphon mean field forward-backward stochastic

differential equations (FBSDEs). We then derive a version of the Pontryagin stochastic maximum principle tailored to GMFC problems. Furthermore, we analyze the solvability of the GMFC problem for linear dynamics and study the continuity and stability of the graphon mean field FBSDEs under the optimal control profile. Finally, we show that the solution to the GMFC problem provides an approximately optimal solution for large systems with heterogeneous mean field interactions, based on a propagation of chaos result. Joint work with Zhongyuan Cao (NYU Shanghai).

- **Title**: Parallelization in large computing systems and fluid-limits of Markov processes

  Speaker: Ravi Mazumdar, University of Waterloo

  Abstract:

- **Title**: Functional Role of Synchronization: A Mean-field Control Perspective

  Speaker: Prashant G. Mehta, University of Illinois Urbana-Champaign

  Abstract: This talk is inspired by questions arising in neuroscience, specifically, related to the functional role of synchronization and neural rhythms in brain function. We adopt a mean-field control framework to model populations of interacting agents–here, neurons–as they seek to coordinate their activity through local feedback. The talk will primarily survey our work that builds on the pioneering contributions of Huang, Malhamé and Caines, extending their insights into new directions inspired by neuroscience.

- **Title**: Bridging Schrödinger and Bass for generative diffusion modeling

  Speaker: Huyên Pham, École Polytechnique, Paris

  Abstract:

- **Title**: Averaging Dynamics, Perron-Frobenius Theory, and an Adaptation Dynamics

  Speaker: Behrouz Touri, University of Illinois Urbana-Champaign

  Abstract: In this talk, we discuss the infinite flow theory for the study of averaging dynamics as it relates to the fundamental contribution of Roland Malhame's to the averaging dynamics literature, namely the introduction and the study of infinite jet flow property. We propose a random-adaptation viewpoint to the averaging dynamics and some interesting parallel properties between the two dynamics. Finally, time permitting, we visit an extension of Perron-Frobenius Theory to a time-varying sequence of stochastic matrices.

- **Title**: Investment in Emissions Abatement Capacity when Consumers Value the Environmental Performance of the Supply Chain

  Speaker: Georges Zaccour, HEC Montréal (with Lijue Lu and Elena Parilina)

  Abstract: We examine the abatement investment and pricing decisions within a supply chain where consumers prioritize environmental performance. The product's green reputation is influenced by the gap between its unit pollution rate and an industry standard that declines over time. The abatement capacity investment is managed by the manufacturer, but the retailer has the option to share the associated cost. Our findings reveal that cost-sharing cooperation achieves an economically Pareto-optimal outcome compared to the no-cost-sharing scenario. From an environmental perspective, while it encourages greater abatement capacity investment and lowers the unit pollution rate, in most cases, the associated increase in demand may counteract these benefits, potentially leading to higher total emissions. Furthermore, as the industry standard declines more rapidly, firms tend to reduce their abatement investments. Lastly, firms with lower initial green reputation or abatement capacity – the "brown firms" – are less likely to catch up with the evolving standard, as higher initial states drive a virtuous cycle of increased investment, enhanced abatement capacity, reduced emissions, and further goodwill gains.