CityU-SCUT Joint Workshop on Stochastic Systems and Processes

Date and Time: 17 June 2013, 9:30 am – 5:30 pm
18 June 2013, 9:30 am – 12:30 pm
Venue: Room B4702, Academic 1, City University of Hong Kong

Programme at a Glance

17 June 2013 (Monday)

A.M. Session	**Chair: Prof Daniel Ho**	
9:30 am – 11:00 am	Prof Peter E. Caines (McGill)	ϵ-Nash Mean Field Games I: Introduction
11:00 am – 11:20 am	Coffee Break	
11:20 am – 12:20 pm	Dr Qingshuo Song (CityU)	Quantile Hedging via the Equivalence of Pure and Randomized Hypothesis Testing
12:20 pm – 2:00 pm	Lunch Break	
P.M. Session	**Chair: Prof Daniel Ho**	
Students Contribution		
2:00 pm – 3:00 pm	1) Shifang Kuang (SCUT)	Stability and Numerical Methods of Nonlinear Stochastic Systems with Time-Delays
3:00 pm – 4:00 pm	2) Lulu Li (CityU)	Practical Consensus in Multi-agent Networks with Communication Constrains
4:00 pm – 4:20 pm	Coffee Break	
4:20 pm – 5:20 pm	3) Xueyan Zhao (SCUT)	Stability of Stochastic Functional Differential Equations (SFDEs)

18 June 2013 (Tuesday)

A.M. Session	**Chair: Prof Daniel Ho**	
9:30 am – 11:00 am	Prof Peter E. Caines (McGill)	ϵ-Nash Mean Field Games II: State Estimation in MFG Systems with Application to Power Markets
11:00 am – 11:20 am	Coffee Break	
11:20 am – 12:20 pm	Dr Ju-Yi Yen (Cincinnati)	Some Examples of Skorokhod Embedding and Their Applications in Finance

Title and Abstracts of Presentation

17 June 2013 (Monday)

A.M. Session: 9:30 am – 11:00 am   Chair: Prof Daniel Ho

9:30 am – 11:00 am   Prof Peter E. Caines, McGill University

Title: ϵ-Nash Mean Field Games I: Introduction

Abstract: Multi-agent competitive and cooperative systems occur in a vast range of designed and natural settings such as communication, environmental, epidemiological, transportation and decentralized renewable energy systems. However, the complexity of such large population stochastic dynamic systems make centralized control infeasible and classical game theoretic solutions intractable.

Inspired by statistical mechanics, ϵ-Nash Mean Field stochastic control (aka Nash Certainty Equivalence (NCE) control) originated in the work of M. Y. Huang, R. Malhame' and the speaker (2003, 2006, 2007) and independently in that of J. M. Lasry and P. L. Lions (2006, 2007). The central idea is that in very large population stochastic dynamic games individual feedback strategies exist for which any given agent will be approximately in a Nash equilibrium with respect to the pre-computable behaviour of the mass of the other agents.

In the general case of populations of agents with non-uniform dynamical parameters, the (infinite population) Mean Field Game (MFG) equations consist of a family of Hamilton-Jacobi-Bellman equations and a corresponding family of McKean-Vlasov (MV) Fokker-Planck–Kolomogorov (FPK) equations linked by the probability distribution of the states of the population (i.e. the mean field). For each generic agent these yield (i) the Nash value of the game, (ii) the best response strategy and (iii) the state distribution of such an agent.

The MFG equations have tractable solutions in the linear quadratic Gaussian (LQG) case which give feedback strategies in the form of a (deterministic) mass feedback combined with a (stochastic) local state feedback; as a result, the MFG methodology yields an "end run" around the intractability of N player stochastic dynamic games in the LQG case.

11:00 am – 11:20 am   Coffee Break

11:20 am – 12:20 pm   Dr Qingshuo Song, City University of Hong Kong

Title: Quantile Hedging via the Equivalence of Pure and Randomized Hypothesis Testing

Abstract: We study the portfolio problem of maximizing the outperformance probability over a random benchmark through dynamic trading with a fixed initial capital. Under a general incomplete market framework, this stochastic control problem can be formulated as a composite pure hypothesis testing problem. We analyze the connection between this pure testing problem and its randomized counterpart, and from latter we derive a dual representation for the maximal outperformance probability. Moreover, in a complete market setting, we provide a closed-form solution to the problem of beating a leveraged exchange traded fund. For a general benchmark under an incomplete stochastic factor model, we provide the Hamilton-Jacobi-Bellman PDE characterization for the maximal outperformance probability.

12:20 pm – 2:00 pm   Lunch Break

P.M. Session: 2:00 pm – 5:20 pm Chair: Prof Daniel Ho

Students Contribution

2:00 pm – 3:00 pm Shifang Kuang, South China University of Technology

Title: Stability and Numerical Methods of Nonlinear Stochastic Systems with Time-Delays

Abstract: Systems Engineering Institute, South China University of Technology Abstract Stochastic perturbations exist inevitably in the real systems and the external environments, which influence the dynamical behavior of systems. As stochastic systems depicted by stochastic differential equations (SDEs) can simulate practical problems truthfully and reflect the dynamical characteristics of natural, social and engineering systems more accurately, they have been widely applied to model the corresponding systems in many fields such as engineering applications, mathematical finance, neural networks, ecology, medicine and control science. The stability and control theory of stochastic systems with various complicated factors such as nonlinearities, time-delays, varying coefficients, Markov jumps and distributed parameters are the current research hotspots. Because of the difficulty in obtaining the explicit solutions of nonlinear SDEs with time-delay, it is an important subject both in theoretical significance and practical application to construct appropriate numerical algorithm for the simulation to the solutions. In this talk, firstly, the Itˆo-formula and Itˆo- Taylor expansion are introduced. Then, the convergence and stability of Milstein method for nonlinear stochastic delay integro-differential equations are investigated.

3:00 pm – 4:00 pm Lulu Li, City University of Hong Kong

Title: Practical Consensus in Multi-agent Networks with Communication Constrains

Abstract: This talk deals with the multi-agent consensus problem subject to communication constrains (quantization and time delays). Solutions of the resulting system are defined in the Filippov sense. For the consensus protocol which only considers quantization effect, we prove that Filippov solutions converge to a practical consensus set in a finite time. For the consensus protocol considering quantization and time delay simultaneously, it is shown that Filippov solutions converge to a practical consensus set asymptotically. Furthermore, how initial state of the agents, time delay and quantization parameter affect the final practical consensus set are discussed. A numerical example is provided to demonstrate the effectiveness of the obtained theoretical results.

4:00 pm – 4:20 pm Coffee Break

4:20 pm – 5:20 pm Xueyan Zhao, South China University of Technology

Title: Stability of Stochastic Functional Differential Equations (SFDEs)

Abstract: Systems Engineering Institute, South China University of Technology, Stochastic perturbations, time-delays and nonlinearities effect generally exist in many real complex systems such as biological systems, communication systems and computing systems, etc., then investigation on the stochastic systems modeled by It^o SFDEs is meaningful. Due to their important theoretical significance and their wide applications, investigation on stability of stochastic systems have received a great deal of attention.

The difficulties for the investigation on SFDEs come from three aspects, i.e. the random- ness, nonlinearities and the time-delays involved. Two important mathematical tools, i.e. the It^o's rule and auxiliary measure functions including Lyapunov functions and Lyapunov functionals have been widely used in dealing with the three aspects.

In our investigation, we establish a new type stability theorem for SFDEs, which is not a direct copy of the basic stability theorem for deterministic functional differential equations (DFDEs). By the new type stability theorem, one can use the most simple Lyapunov functions and employ the equations repeatedly to deal with the delayed terms encountered conveniently and to carry out fine stability criteria for the equations. As an application, the asymptotic stability of SFDEs with distributed and variable delays in the diffusive terms is investigated and a stability criteria for SFDSs is obtained, which is described by algebraic matrix equations and cannot obtained by the Lyapunov functional method.

18 June 2013 (Tuesday)

A.M. Session: 9:30 am – 12:00 am   Chair: Prof Daniel Ho

9:30 am – 11:00 am   Prof Peter E. Caines, McGill University

Title: ϵ-Nash Mean Field Games II: State Estimation in MFG Systems with Application to Power Markets

Abstract: A key, counterintuitive feature of the basic Mean Field Games (MFG) theory is that the mean field of a stochastic dynamic game between a set of asymptotically negligible (so-called Minor) agents is deterministic. However, when a Major player is present the mean field becomes stochastic (M.Y. Huang; SICON, 2010; S. Nguyen, M. Y. Huang; SICON, 2012; M. Nourian, P. E. Caines, SICON, 2013). Hence recursive estimation of both the Major agent's state and the mean field is required in those cases where they are only partially observed (i.e. observations are disturbed by noise).

In this talk, for those linear quadratic Gaussian MFG problems where there is a Major agent, we present feedback control laws based upon recursive estimation which achieve (i) an ϵ-Nash equilibrium (with ϵ vanishing as the population goes to infinity) and (ii) individual L^2 stability.

Next, following (A. C. Kizilkale, S. Mannor, P. E. Caines; CDC 2012), we describe a power market model using the theory of stochastic dynamic large population games where suppliers and consumers submit their bids in real-time and the agents are coupled in their dynamics and cost functions through the price process. Extending the model of (KMC; CDC2012), a common stochastic Partially Observed Neutral Major Agent is used to model common unpredictable disturbance factors (e.g. wind) and exogenous market factors (e.g. competing energy resource prices). The extended MFG theory above is then applied to obtain simple decentralized control actions achieving an ϵ-Nash equilibrium and individual L^2 stability.

Work with Arman Kizilkale

11:00 am – 11:20 am   Coffee Break

11:20 am – 12:20 pm   Dr Ju-Yi Yen, University of Cincinnati

Title: Some Examples of Skorokhod Embedding and Their Applications in Finance

Abstract: Given a target probability measure μ, Skarokhod embedding problem consists of finding a stopping time T of Brownian motion $(B_t)_{t\geq 0}$ such that $B_{t\wedge T}$ is a uniformly integrable martingale; and B_T has the given law μ. The Skorokhod embedding problem has generated recent interest, motivated by connection to optimal stopping problems. The optimal stopping problem in mathematical finance is concerned with choosing a time (or a family of times) to exercise an exotic option, such that, the reward is maximized (or the cost minimized). We shall illustrate the optimal stopping problems in mathematical finance via existing Skorokhod embedding algorithms.