Atelier Quantact de mathématiques financières

Quantact workshop on financial mathematics

● **Résumés / Abstracts** ●

Comité organisateur / Organizing committee :

Maciej Augustyniak (Université de Montréal)
Frédéric Godin (Concordia University, Université Laval)
Anne MacKay (UQAM)

Commanditaires / sponsors :

Quantact, the Centre de recherches mathématiques (CRM)
Laboratory of Actuarial and Financial Mathematics

NSERC-CREATE Program on Machine Learning in
Quantitative Finance and Business Analytics (Fin-ML CREATE)

Atelier Quantact de mathématiques financières

Vendredi, 31 mai 2019

Quantact workshop on financial mathematics

Friday, May 31st, 2019

Université de Montréal
Pavillon André-Aisenstadt
AA-1175

9:30 - 10:30 – Blanka Horvath, King's College London
Deep learning volatility

10:30 - 11:00 - Pause café / Coffee Break

11:00 - 12:00 – Juan-Pablo Ortega, University of St. Gallen & CNRS
The universality problem in dynamic machine learning with applications to realized covolatilities forecasting

12:00 - 14:30 – Dîner / Lunch

14:30 - 15:30 – Jean-François Bégin, Simon Fraser University
Likelihood evaluation of jump-diffusion models using deterministic nonlinear filters

15:30 - 16:00 - Pause café / Coffee Break

16:00 - 17:00 – Rogemar Mamon, Western University
The valuation of a guaranteed minimum maturity benefit under a regime-switching framework

Deep learning volatility

Blanka Horvath
King's College London

We present a consistent neural network based calibration method for a number of volatility models—including the rough volatility family—that performs the calibration task within a few milliseconds for the full implied volatility surface. The aim of neural networks in this work is an off-line approximation of complex pricing functions, which are difficult to represent or time-consuming to evaluate by other means. We highlight how this perspective opens new horizons for quantitative modelling: The calibration bottleneck posed by a slow pricing of derivative contracts is lifted. This brings several model families (such as rough volatility models) within the scope of applicability in industry practice. As customary for machine learning, the form in which information from available data is extracted and stored is crucial for network performance. With this in mind we discuss how our approach addresses the usual challenges of machine learning solutions in a financial context (availability of training data, interpretability of results for regulators, control over generalisation errors). We present specific architectures for price approximation and calibration and optimize these with respect different objectives regarding accuracy, speed and robustness. We also find that including the intermediate step of learning pricing functions of (classical or rough) models before calibration significantly improves network performance compared to direct calibration to data.

The universality problem in dynamic machine learning with applications to realized covolatilities forecasting

Juan-Pablo Ortega
University of St. Gallen & CNRS

We will start by showing how a relatively recent family of dynamic machine learning paradigms known collectively as “reservoir computing” are capable of unprecedented performances in the forecasting of deterministic (chaotic attractors) and stochastic processes (financial realized covariance matrices). We will then focus on the universal approximation properties with respect to uniform and L^p criteria of the most widely used families of reservoir computers in applications. These results are a much awaited generalization to the dynamic context of the well-known static results obtained by Cybenko and Hornik et al. in the context of neural networks.

Likelihood evaluation of jump-diffusion models using deterministic nonlinear filters

Jean-François Bégin
Simon Fraser University

Most financial assets exhibit stochastic volatility and jumps. Indeed, over the past thirty years, jump-diffusion models have been widely used as they can reproduce some of these important stylized facts and allow for closed-form solutions for option prices. Yet, the estimation of parameters of stochastic volatility models with jumps is cumbersome as the latter variables are not directly observed. In practice, sequential Monte Carlo methods—so-called particle filters—are used to compute and maximize the likelihood function. A significant caveat of this methodology, however, is that the likelihood function is not smooth for a finite set of particles and thus computationally intensive to maximize.

In this study, we present a deterministic nonlinear filtering algorithm based on a high-dimensional version of Kitagawa (1987) to evaluate the likelihood function of models that allow for stochastic volatility and jumps. Efficient and precise likelihood evaluation is indeed important for not only frequentist-based maximum likelihood estimation but also Bayesian inference. We show numerically that the deterministic filtering method is precise and much faster than the particle filter, in addition to yielding a smooth function over the parameter set. Using GPU-based CUDA programming, we also illustrate how to streamline the methodology to models with stochastic arrival intensity of jumps and estimate these models with financial data such as stock indices.

Joint work with Mathieu Boudreault, Université du Québec à Montréal.

The valuation of a guaranteed minimum maturity benefit under a regime-switching framework

Rogemar Mamon
Western University

The global insurance markets have become more sophisticated in recent times in response to the evolving needs of population that tends to live longer. Policy holders desire the benefits of longevity/mortality protection whilst taking advantage of investment growth opportunities in the equity markets. As a result, insurers incorporate payment guarantees in new insurance products known as equity-linked contracts whose values are dependent on prices of risky assets. A guaranteed minimum maturity benefit (GMMB) is now common in many equity-linked contracts. We develop an integrated pricing framework for a GMMB focusing on segregated fund contracts. More specifically, we construct hidden Markov models (HMMs) for a stock index, interest rate and mortality rate. The dependence between these risk factors are characterised explicitly. We assume that the stock index follows a Markov-modulated geometric Brownian motion whilst the interest and mortality rates have Markov-modulated affine dynamics. A series of measure changes is employed to obtain a semi-closed form solution for the GMMB price. The Fourier-transform method is applied to numerically approximate the prices more efficiently. Recursive HMM filtering is used in our model calibration. Numerical investigations in our paper demonstrate the accuracy of GMMB prices and an extensive analysis is included to examine systematically how risk factors affect the value of a GMMB.

Joint work with Yixing Zhao.