Numerical Methods for Finance (COMP0043)

Description

Aims:
An introduction to numerical/computational methods with code examples (Matlab, C++, Python) and an emphasis on applications in finance (derivatives pricing, model calibration, etc.).

Learning outcomes:
Programming proficiency and demonstrable skills in turning mathematical equations and models into working code; capacity to solve practical problems in financial mathematics applying modern numerical techniques.

Content:
1. Introduction:
Bibliography, programming languages, programming basics: data types, operators, expressions, control structures (iteration i.e. for-loop, conditional execution i.e. if-then-else, etc.), vector/array operations, input/output, plots, etc. Floating-point representation of real numbers, numerical errors.
2. Fundamental probability distributions:
Normal, exponential, log-normal, chi square, etc; plot of the probability distribution function, sampling with pseudo-random numbers, histograms, transformation from uniform to other distributions using the quantile function, i.e. the inverse cumulative distribution function.
3. Random numbers:
Linear congruential generators, requirements and statistical tests, pathologic cases, more advanced generators; inversion and transformation in one and more dimensions, acceptance-rejection method, Box-Muller method for normal deviates, polar method by Marsaglia, Ziggurat algorithm by Marsaglia and Tsang, correlated normal random variates, quasi-random numbers.
4. Monte Carlo methods:

Key information

Year 2019/20
Credit value 15 (150 study hours)
Delivery PGT L7, Campus-based
Reading List View on UCL website
Tutor Dr Guido Germano
Term Term 1
Timetable View on UCL website

Assessment

Written examination (main exam period): 60%
Written examination (departmentally managed): 20%
Written examination (departmentally managed): 20%

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For more information about the department, programmes, relevant open days and to browse other modules, visit ucl.ac.uk

Disclaimer: All information correct as of August 2019. Please note that aspects of the module may be subject to change. UCL will make best efforts to inform applicants of major changes.
5. Important stochastic differential equations:
   Arithmetic and geometric Brownian motion,
   Ornstein-Uhlenbeck process and Vasicek model,
   Feller square-root process and Cox-Ingersoll-Ross
   model, constant elasticity of variance processes,
   Brownian bridge, Heston stochastic volatility
   model.
6. Stochastic processes with jumps:
   Poisson process, normal compound Poisson
   process, Gamma process, jump-diffusion
   processes (Merton, Kou), time-changed Brownian
   motion (variance Gamma process), Lévy
   processes.
7. Black-Scholes option pricing:
   A simple program that prices European calls and
   puts with the analytical solution, the analytical
   solution provided by Matlab's Financial Toolbox,
   the fast Fourier transform, and Monte Carlo.
8. Model calibration:
   Implied volatility, Newton-Raphson method,
   Jäckel's equivalent form, Jäckel's modification,
   complex initial guess and fractals.
9. Fourier transform methods:
   Definitions of the Fourier transform, inverse
   transform, notable transform pairs (normals, double
   exponential/Lorentzian, Dirac delta/1), discrete and
   fast Fourier transform, Laplace transform, transform
   of the derivative, solution of the standard diffusion
   equation by Fourier transform and in
   Fourier-Laplace space, fractional derivatives,
   space-time fractional diffusion equation and its
   solution in Fourier-Laplace space, characteristic
   function, moment-generating function,
   cumulant-generating function, Lévy processes,
   correlation/convolution theorem,
   auto/cross-covariance and correlation,
   Parseval/Plancherel theorem, shift theorem, use in
   option pricing.
10. Exotic options:
    Fourier methods for the numerical pricing of
    discretely and continuously monitored
    path-dependent options like barrier and lookback.
11. Partial differential equations:
    Classification, second-order PDEs, notable
    examples of elliptic, parabolic and hyperbolic
    PDEs, diffusion equation, Black-Scholes equation,
    Feynman-Kac theorem and relationship with SDEs,
    finite difference schemes.

Requisites:
In order to be eligible to select this module, a
student must be registered on a programme for
which it is a formally-approved option or elective
choice AND must have taken COMP0041 and
"Introduction to Mathematics and Programming for
Finance".