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:

Assessment

- Written examination (main exam period): 60%
- Written examination (departmentally managed): 20%
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Disclaimer: All information correct as of June 2019. Please note that aspects of the module may be subject to change. UCL will make best efforts to inform applicants of major changes.


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.


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".