BiiPS software: statistical learning in finance

ALEA project-team, Inria Bordeaux – Sud-Ouest

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Context

The last two decades have seen a rapid development of increasingly **realistic and sophisticated stochastic models and methods** for **pricing**, **hedging** and **risk management in rapidly growing markets**.

Problem

Modern finance is becoming **increasingly technical**, requiring the use of **advanced stochastic algorithms**.

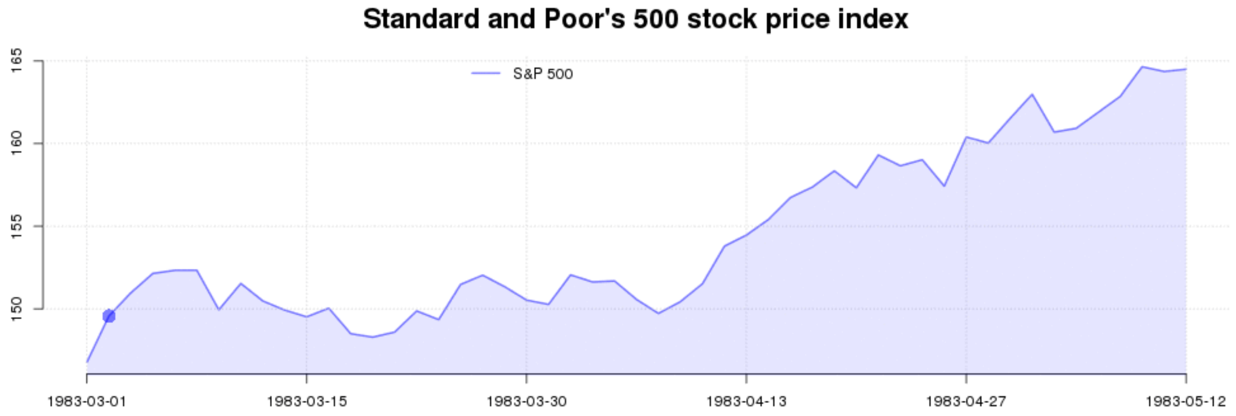
1

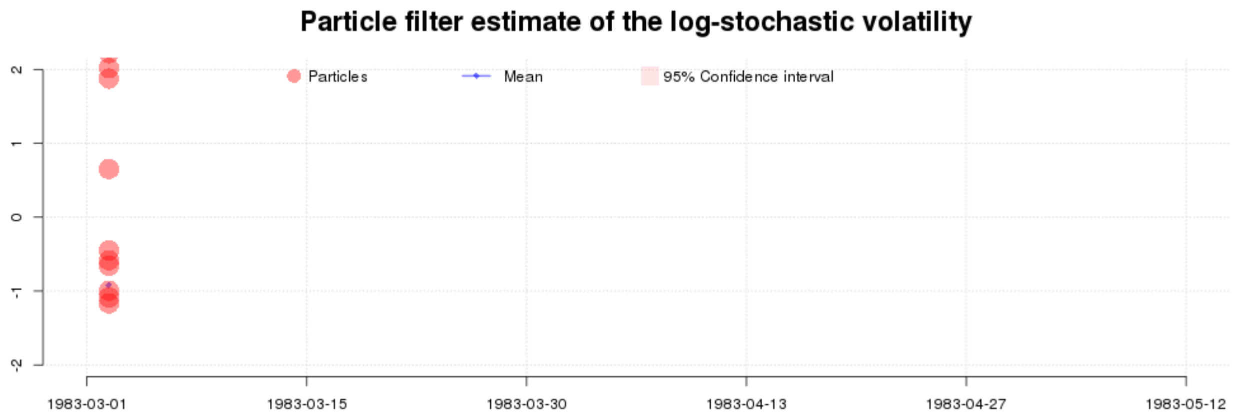
Advanced Particle and Sequential Monte Carlo Algorithms

Our expertise

As a pioneer in the field of **new adaptive and interacting particle algorithm** and **SMC methods**, the ALEA project-team is working on **a great variety of numerical applications**.

Particle algorithms illustrated





Numerical applications

- Parameter estimation
- Calibration of valuation models
- Derivative pricing
- Sensitivity analysis
- Hedging in incomplete markets
- Credit risk
- Risk and uncertainty quantification
- Portfolio optimization
- Etc.

Team members implied in financial mathematics:
P. Del Moral, P. Hu, A. Richou, F. Caron, A. Todeschini, C. Li (Master X2009).

2
The software BiiPS

A **new software** for Bayesian inference using interacting particle systems

Design and development: ***A. Todeschini***

Free and open source software soon available for Windows, Linux and Mac OS at ***http://biips.gforge.inria.fr***

Model definition

Simple and generic
Arbitrary complexity

Bayesian networks
Hidden Markov models

Observed data

Input

Black box and powerfull inference engine using particle methods

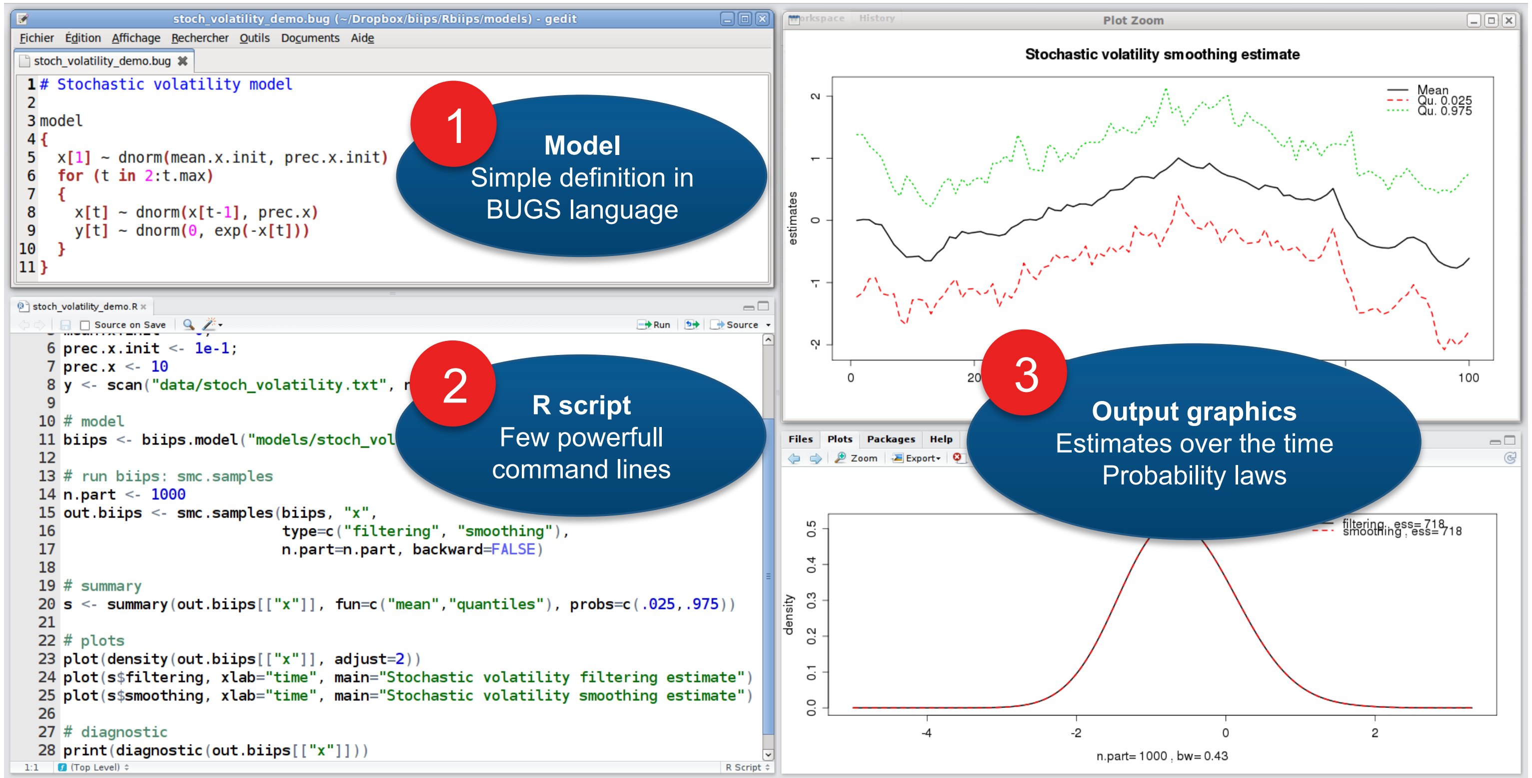
Summary Statistics

Full description of the posterior probability law

Output

Financial models calibration

Stochastic volatility / Partial observations



***Future works**: Matlab interface, Parallelization and more…*

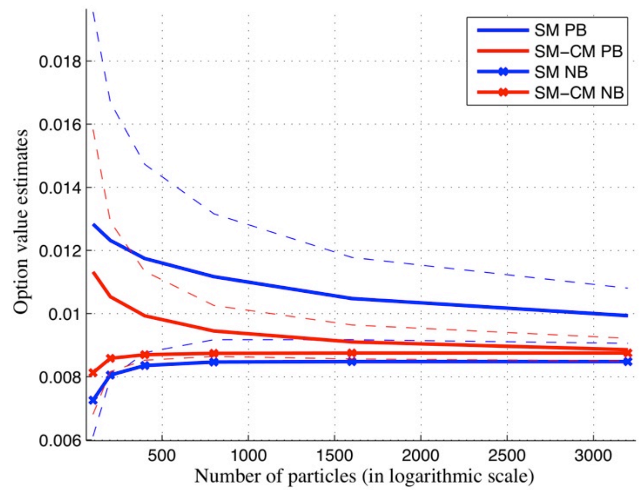
3

More finance applications

Pricing financial products

European barrier options, Asian options, American options,…

Pricing efficiency improved by using advanced particle estimation



Monte Carlo estimates vs. **advanced particle estimates**

Mathematical tools:

- Optimal control
- Particle approximation of Snell envelope

Payoff	K	$d=1$	$d=2$	$d=3$	$d=4$	$d=5$
Geometric	0.95	1 (1%)	1 (3%)	1 (6%)	1 (9%)	1 (10%)
Put	0.85	5 (2%)	8 (6%)	6 (11%)	4 (14%)	3 (14%)
	0.75	18 (6%)	28 (11%)	18 (17%)	16 (18%)	11 (16%)
Arithmetic	0.95	1 (1%)	3 (2%)	3 (7%)	4 (13%)	5 (18%)
Put	0.85	5 (2%)	13 (6%)	24 (19%)	56 (24%)	100 (20%)
	0.75	18 (6%)	71 (15%)	363 (14%)	866 (16%)	– (–)

Ratios of estimated MC results vs. advanced particle results

References:

- R. Carmona, P. Del Moral, P. Hu and N. Oudjane (eds.), Numerical Methods in Finance, to appear, Springer-Verlag.
- R. Carmona, P. Del Moral, P. Hu and N. Oudjane, "An introduction to particle methods in finance" [43 pages], to appear in Numerical Methods in Finance.
- P. Del Moral, P. Hu and N. Oudjane, "Snell Envelope with small probability criteria" [22 pages], preprint inria-00507794 [submitted], 2010.
- P. Del Moral, P. Hu, N. Oudjane and B. R´emillard, "On the Robustness of the Snell Envelope" [40 pages], SIAM J. Finan. Math., Vol. 2, pp. 587–626, 2011.

Collaboration:
EDF R&D

Hedging

Greeks calculation

Mathematical tools:

- Sequential Monte Carlo particle methods
- Particle gradient models

References:

- R. Carmona, P. Del Moral, P. Hu and N. Oudjane (eds.), Numerical Methods in Finance, to appear, Springer-Verlag.
- R. Carmona, P. Del Moral, P. Hu and N. Oudjane, “An introduction to particle methods in finance” [43 pages], to appear in Numerical Methods in Finance.
- P. Del Moral, P. Hu and L. Wu, On the concentration properties of Interacting particle processes, Foundations and Trends in Machine Learning, vol. 3, nos. 3–4, pp. 225–389, 2012.

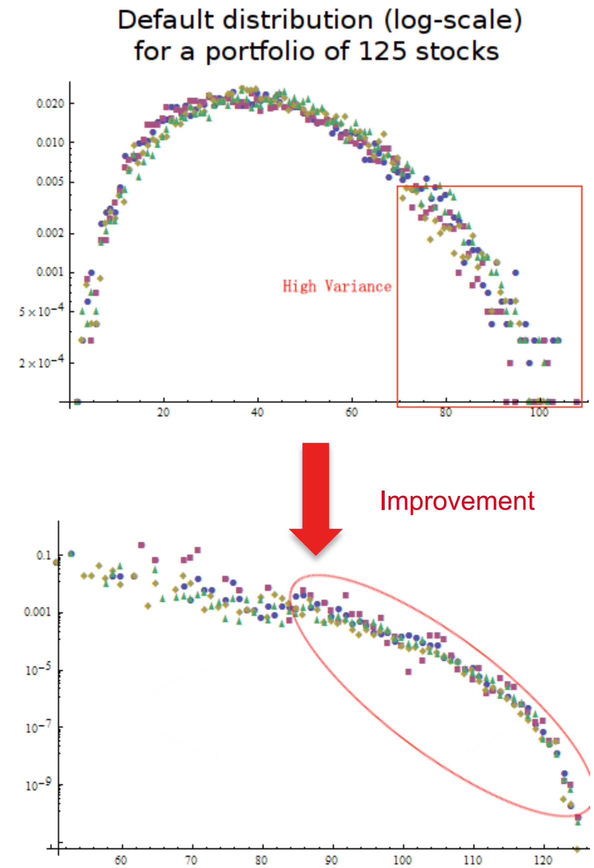
Credit Risk
Default Probability

Mathematical tools:

- Rare event simulation
- Particle default tree models

References:

- R. Carmona, P. Del Moral, P. Hu and N. Oudjane, “An introduction to particle methods in finance” [43 pages], to appear in Numerical Methods in Finance.
- R. Carmona and S. Crépey. Importance Sampling and Interacting Particle Systems for the Estimation of Markovian Credit Portfolios Loss Distribution. International Journal of Theoretical and Applied Finance, vol. 13, No. 4 (2010) 577 – 602.
- R. Carmona, J.-P. Fouque and D. Vestal. Interacting Particle Systems for the Computation of Rare Credit Portfolio Losses. Finance and Stochastics, vol. 13, no. 4, 2009 pp. 613-633 (2009).



Rare credit portfolio losses are better captured with advanced particle estimation

Portfolio optimization

Maximizing expected utility function of the terminal wealth

Mathematical tools:

- Abstract solutions with backward SDEs

References:

- Y. Hu, P. Imkeller, M. Müller, "Utility maximization in incomplets markets." Ann. Appl. Probab., 15(3): 1691-1712, 2005.
- Y. Hu, P. Imkeller, M. Müller, "Partial equilibrium and market completion." Int. J. Theor. Appl. Finance, 8(4): 483-508, 2005.
- U. Horst, Y. Hu, P. Imkeller, A. Réveillac, J. Zhang, "Forward-backward systems for expected utility maximization", Preprint, 2011.

- Numerical simulation: time discretization of the solution of quadratic backward SDEs

References:

- A. Richou, "Numerical simulation of BSDEs with drivers of quadratic growth." Ann. Appl. Probab., 21 (5) :1933-1964.
- A. Richou, "Markovian quadratic and superquadratic BSDEs with an unbounded terminal condition." Preprint, 2012.
- A. Richou, "Etude théorique et numérique des équations différentielles stochastiques rétrogrades", PhD thesis, Univ. Rennes 1, 2010.

Collaborations

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Conference information

Workshop on Sequential Monte Carlo methods and Efficient simulation in Finance.

ALEA – CMAP. *Ecole Polytechnique, Paris October 8-12th, 2012*