Internship at Sorbonne Université
Laboratoire de Probabilités Statistique et Modélisation

Subject: Learning price and sensitivities using the regularity of the stochastic flow

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Keywords Sobolev training, Hull and White model, Malliavin calculus, High Performance Computing

Starting period: February-April 2026 **Internship duration:** 6 months

Context of the work: This internship is a part of the "Capital Markets Tomorrow: Modeling and Computational Issues" chair under the aegis of the Institut Europlace de Finance, a joint initiative of Laboratoire de Probabilités, Statistique et Modélisation (LPSM), Université Paris Cité and Crédit Agricole CIB.

The proposed internship is motivated by the growing role of machine learning in quantitative finance, not only as a means of functional approximation but, more importantly, as a powerful tool for process automation. In addition to the theoretical groundwork required to master the underlying concepts, the internship will place substantial emphasis on numerical implementation and critical reflection on their practical applicability. Engagement with industry practitioners will be facilitated to gain insight into the challenges associated with scaling and deploying the developed methodologies in real-world financial contexts.

Upon successful completion of the internship, the student may be offered the opportunity to pursue a thesis, with supervision and/or funding provided, on a topic that constitutes a natural continuation of the work undertaken during the internship.

Description and key developments: Motivated by the success of "Sobolev training" techniques in improving the smoothness and generalization of neural networks (cf. [1]) and their effective application to quantitative finance problems (cf. [2]), this work aims to develop a systematic framework for the computation of financial contract prices and their higher-order sensitivities using Adjoint Algorithmic Differentiation (AAD).

The proposed framework will allow for the efficient evaluation of first-, second-, and higher-order derivatives (Greeks) with respect to model parameters within a unified AAD-based approach. In cases where the cash flows exhibit non-differentiability, the study will incorporate tools from Malliavin calculus (cf. [3]) and exploit the regularity properties of stochastic flows to obtain higher-order derivative estimates in a mathematically rigorous way.

The primary model considered in this work, chosen for its simplicity and robustness, is the Hull–White (HW) model for fixed-income derivative contracts (cf. [4]). Owing to its analytical tractability, the HW model provides a convenient benchmark and allows extensive testing across a wide range of fixed-income products, including those involving early optimal stopping features, which can be efficiently implemented on GPUs. In addition,

alternative models such as mixtures of geometric Brownian motions will be investigated for comparative analysis.

Required Qualifications: As the subject lies at the intersection of advanced mathematical methodologies such as stochastic analysis applied to finance and high-performance computing on GPUs for machine learning, applications from candidates with a strong background in applied mathematics or computer science are particularly encouraged. The selected student will receive dedicated mentorship and guidance to develop any additional skills required to successfully carry out the project.

Application Process: Please send your resume and a short cover letter explaining your interest in this internship to `lokmane.abbas_turki@sorbonne-universite.fr` before December 12th, 2025.

References

[1] Czarnecki, W. M., Osindero, S., Jaderberg, M., Swirszcz, G., and Pascanu, R. (2017). Sobolev training for neural networks. *Advances in neural information processing systems, 30*

[2] Huge, B., and Savine, A. (2020). Differential machine learning. *arXiv preprint arXiv:2005.02347.*

[3] Bally, V. (2003). *An elementary introduction to Malliavin calculus.* RR–4718. INRIA, 2003.

[4] Brigo, D., and Mercurio, F. (2006). *Interest rate models—Theory and practice: With smile, inflation and credit.* Springer Berlin Heidelberg.