Justin Sirignano

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Appointments

Associate Professor, University of Oxford — July 2020-
Mathematical Institute
Member of the Mathematical & Computational Finance Group
Member of the Data Science Group

Assistant Professor, University of Illinois at Urbana-Champaign — Aug. 2016-
College of Engineering
Department of Industrial & Enterprise Systems Engineering
Coordinated Science Lab (Signals, Inference, & Networks group)

Chapman Fellow, Imperial College London — 2015-2016
Department of Mathematics

Education

Stanford University, PhD — 2010-2015

Princeton University, B.S.E. — 2006-2010
Graduated *summa cum laude*
Elected to Phi Beta Kappa, Tau Beta Pi, and Sigma Xi

Research Interests

- Mathematics of Machine Learning and Deep Learning
- Mathematical Finance
- Applications of machine learning to partial differential equation models

Research Publications

- Mathematics of Machine Learning and Deep Learning

    1. "Mean Field Analysis of Deep Neural Networks" (with K. Spiliopoulos).
    Mathematics of Operations Research, accepted for publication, 2020.
    2. "Mean Field Analysis of Neural Networks: A Law of Large Numbers" (with K. Spiliopoulos).
    SIAM Journal on Applied Mathematics, 80 (2), 725-752, 2020.
    3. "Mean Field Analysis of Neural Networks: A Central Limit Theorem" (with K. Spiliopoulos).
    Stochastic Processes and their Applications, 130 (3), 1820-1852, 2020.
    4. "Stochastic Gradient Descent in Continuous Time: A Central Limit Theorem" (with K. Spiliopoulos).
    Stochastic Systems, 10 (2), 2020.
    5. "Asymptotics of Reinforcement Learning with Neural Networks" (with K. Spiliopoulos).
    Invited Revision at *Stochastic Systems*, arXiv:1911.07304, 2019.

- Mathematical Finance

6. "Inference for Large Financial Systems" (with G. Schwenkler and K. Giesecke).
   Mathematical Finance, 2020.
7. "DGM: A Deep Learning Algorithm for solving Partial Differential Equations" (with K. Spiliopoulos).
   Journal of Computational Physics, 375, 1339–1364, 2018.
8. "Stochastic Gradient Descent in Continuous Time" (with K. Spiliopoulos).
   SIAM Journal on Financial Mathematics, 8(1), 933-961, 2017.
9. "Large Portfolio Asymptotics for Loss from Default" (with K. Giesecke, K. Spiliopoulos, and R. Sowers).
   Mathematical Finance, 25(1), 77-114, 2015.
10. "Large-scale Loan Portfolio Selection" (with K. Giesecke and G. Tsoukalas).
    Operations Research, 64(6), 1239-1255, 2019.
11. "Risk Analysis for Large Pools of Loans" (with K. Giesecke). **Winner of the inaugural SIAM Financial Mathematics & Engineering Conference Paper Prize.**
    Management Science, 65 (1), 107-121, 2018.
12. "Deep Learning for Limit Order Books."
    Quantitative Finance, 2018. arXiv:1601.01987
13. "Universal Price Formation in Financial Markets: Insights from Deep Learning" (with Rama Cont).
    Quantitative Finance, 2019.
14. "Deep Learning for Mortgage Risk" (with K. Giesecke and A. Sadhwani), arXiv:1607.02470.
    Journal of Financial Econometrics, accepted 2020.

- Applications of Machine Learning to PDEs

15. "DPM: A deep learning PDE augmentation method with application to large-eddy simulation" (with J. Freund and J. MacArt).
    Journal of Computational Physics, 423, 2020.
16. "Embedded training of neural-network sub-grid-scale turbulence models" (with J. Freund and J. MacArt).
    Invited Revision at *Physical Review of Fluids*, 2020.
17. "Optimization of Secondary-Air Addition in a Continuous One-Dimensional Spray Combustor" (with L. Rodriquez, A. Siders, and W. Sirignano).
    Journal of Propulsion and Power, 26(2), 288-294, 2010.

Research Publications in Preparation

1. "An Online Adjoint Algorithm for Optimizing Partial Differential Equations" (with K. Spiliopoulos).
2. "A Large Deviation Principle for Neural Networks" (with K. Spiliopoulos).
3. "Deep Learning Closure Models for Partial Differential Equations" (with J. MacArt).
4. "Deep Reinforcement Learning for Optimal Execution of Portfolio Transactions" (with X. Dong).
5. "Machine Learning Models for Pricing and Hedging Financial Derivatives" (with L. Fan).
6. "Global Convergence of Actor-Critic Algorithms in Deep Reinforcement Learning" (with Z. Wang).

Other Publications

1. "Deep Learning: Theory and Computation." In preparation and invited to be published by *Cambridge University Press*. Book proposal was peer-reviewed.

2. "Deep Learning Models in Finance."
SIAM News, June 2017.

3. Book review of "Deep Learning" by Goodfellow, Bengio, and Courville.
SIAM Review, 2018.

4. "A Forward-Backward Algorithm for Stochastic Control Problems" (with S. Ludwig, R. Huang, and G. Papanicolaou).
Proceedings of the First International Conference on Operations Research and Enterprise Systems, February 2012.

Selected Presentations

1. Seminar at Brown University, Division of Applied Mathematics, Spring 2021.

2. Seminar at University of Minnesota, Dept. of Mathematics, February 2021.

3. SIAM Conference on Financial Mathematics, Invited Presentation, 2021.

4. SIAM Conference on Applications of Dynamical Systems, Invited Presentation, 2021.

5. Seminar in Physics & Machine Learning, University of Oxford, November 2020.

6. Invited presentation at Maven Securities, London (virtual), October 2020.

7. NSF Workshop on *Machine Learning in Transport Phenomena* in Dallas, Texas, February 2020. Distinguished Speaker.

8. Two Sigma Investments, New York City, January 2020. Invited seminar.

9. Seminar at the University of Oxford, Dept. of Mathematics, October 2019. *Mathematical Finance* seminar.

10. Seminar at the University of Oxford, Dept. of Mathematics, October 2019. *Data Science* seminar.

11. Seminar at University of Michigan, Dept. of Mathematics, October 2019.

12. Colloquium at UCLA, Dept. of Mathematics, May 2019.

13. Workshop on Machine Learning at the University of Toronto, Fields Institute, September 2019. Invited Speaker.

14. Seminar at Carnegie Mellon University, Dept. of Statistics, January 2019.

15. Seminar at Columbia University, Dept. of Industrial Engineering & Operations Research, February 2019.

16. SIAM Financial Mathematics conference, June 2019.

17. SIAM Annual Meeting, July 2018.

18. London Quantitative Finance Seminar, May 2018.

19. Deep Learning Workshop, National Center for Supercomputing Applications, UIUC, October 2017.

20. Seminar at Princeton University, Dept. of Operations Research and Financial Engineering, 2017.

21. INFORMS Applied Probability Society Conference, Northwestern University, July 2017. Invited.

22. Seminar at Northwestern University, April 2017.
23. J.P. Morgan, New York City, August 2017. Invited seminar.
24. Seminar at UIUC Business School, February 2017.
25. SIAM Financial Mathematics Conference, Austin, Texas, November 2016. Co-organized minisymposium on machine learning in finance.
26. Bank of England, London, May 2016. Invited seminar.
27. INFORMS Annual Meeting, Nashville, November 2016. Invited.
28. Seminar at London Business School, London, June 2016.
29. Seminar at Oxford University, May 2016.
30. London-Paris Bachelier Workshop on Mathematical Finance, London, September 2015. Invited.
31. Lending Club, San Francisco, June 2015.
32. IPAM Workshop on Systemic Risk and Financial Networks, Los Angeles, 2015.
33. SIAM Financial Mathematics and Engineering Meeting, Chicago, 2014. Invited.
34. INFORMS Annual Meeting, San Francisco, 2014. Invited.
35. Joint Mathematics Meeting, Baltimore, 2014. Invited.
36. INFORMS Annual Meeting, Phoenix, October, 2012. Invited.
37. SIAM Financial Mathematics and Engineering Meeting, Minneapolis, 2012. Chair of the *Credit Risk* session.
38. Annual Meeting of the Canadian Applied and Industrial Mathematics Society, Toronto, 2012. Invited.
39. 5th Financial Risks International Forum, Paris, France, 2012.

Grants

1. Co-PI on $17 million DoE/NNSA PSAAP III Center.
2. 44 million core hours on the Blue Waters national supercomputer (value of $861,000).
3. $120,000$ GPU hours on the Summit national supercomputer.

Awards and Honors

1. Chapman Fellowship at Imperial College London
2. Winner of the inaugural SIAM Financial Mathematics & Engineering Conference Paper Prize.
3. Distinguished Speaker at the NSF Workshop on *Machine Learning in Transport Phenomena* in Dallas, Texas, 2020.
4. Rose Hills Foundation Engineering Fellowship at Stanford University.
5. Lore von Jaskowsky Memorial Prize, School of Engineering and Applied Sciences at Princeton University, for senior thesis research.

Teaching

1. "Deep Learning" (Spring 2021) at the University of Oxford.
2. "Numerical Methods" in computational finance (Fall 2020) at the University of Oxford.
3. "Deep Learning" (Fall 2016, 2017, 2018, 2019). Graduate course, cross-listed between Industrial Engineering and Computer Science. 200 graduate students (PhD and Masters) enrolled in Fall 2019 from Computer Science, Electrical Engineering, Industrial Engineering, Mechanical Engineering, and Mathematics.
4. "Deep Learning" (Spring 2018, 2019). Undergraduate course.
5. "Deep Learning II" (Spring 2018). Graduate course.
6. "Analysis of Data" (Spring 2017, Spring 2018). Undergraduate course.
7. "Machine Learning" (Spring 2016, Imperial College London, Dept. of Mathematics). Graduate course.

Graduate Students

1. Xiaobo Dong (ISE, UIUC, 2021). PhD Thesis: "Deep Reinforcement Learning Models of High Frequency Financial Data".
2. Lei Fan (ISE, UIUC, 2021). PhD Thesis: "Machine Learning Methods for Pricing and Hedging Financial Derivatives".
3. Deqing Jiang (Math, Oxford, 2024). PhD Thesis on deep reinforcement learning and mathematical finance. PhD funded by Alan Turing Institute.
4. Ziheng Wang (Math, Oxford, 2024). PhD Thesis on mathematics of deep reinforcement learning. PhD funded by HSBC.
5. Michael Giegrich (Math, Oxford, 2024). PhD Thesis on machine learning methods for pricing and hedging asset-backed securities. PhD funded by Deutsche Bank.
6. Filippo De Angelis (Math, Oxford, 2024). PhD Thesis on developing stochastic differential equation models using machine learning. PhD funded by HSBC.
7. Abhinav (CS, UIUC, 2019). Masters Thesis: "Deep Learning Models of High Frequency Data ".

Professional Activities

1. Director of Masters program in Mathematical & Computational Finance at the University of Oxford.
2. Member of committee for the UIUC Masters of Financial Engineering program.
3. Associate Editor, *Mathematical Finance*.
4. Managing Editor, *Quantitative Finance*.
5. Associate Editor, *Journal of Dynamics and Games* (an AIMS journal).
6. Invited participant and speaker at "Theory of Deep Learning" at the Alan Turing Institute, London, 2020. (Now postponed.)
7. Invited participant of 2021 research program "Mathematics of Deep Learning" at the Isaac Newton Institute for Mathematical Sciences" at the University of Cambridge.
8. Associate Editor, Special Issue of *Management Science* on Data-Driven Prescriptive Analytics.
9. Organized Minisymposiums and Sessions
   (i) Invited minisymposium organizer at SIAM Annual Meeting, Toronto, 2020.

(ii) *Machine learning* minisymposium at SIAM Financial Math Meeting, Toronto, June 2018. 12 speakers.

(iii) *Machine learning in finance* session at INFORMS Annual Meeting, Houston, October 2017.

(iv) *Financial engineering* session at INFORMS Applied Probability Meeting, Northwestern University, July 2017.

(v) *Machine learning for finance* minisymposium at SIAM Financial Mathematics Conference, Austin, November 2016.

(vi) *Machine learning for finance* session at INFORMS Annual Meeting, Nashville, November 2016.

(vii) *Large-scale portfolio risk* session at INFORMS Annual Meeting, Philadelphia, November 2015.

10. Referee for *SIAM Journal on Data Science*, *SIAM Journal on Financial Mathematics*, *NeurIPS*, *Constructive Approximation* (Special Issue on Deep Learning), *Stochastic Systems*, *Journal of Machine Learning Research*, *Journal of Computational Physics*, *Quantitative Finance*, *Operations Research*, *Management Science*, *Nature Communications*, and other journals.

11. Campus collaborator for the Deep Learning Major Research Instrument Project (approx. $2 million), which is developing a high-performance cluster specifically designed for deep learning and will provide unprecedented computational performance for deep learning applications.

Other work experience

British Petroleum, Natural Gas & Power (NAGP), Summer 2013. Machine learning models for electric power market.

Citizenship

United States of America