

Justin Sirignano

Website: <https://www.maths.ox.ac.uk/people/justin.sirignano>
Email: Justin.Sirignano@maths.ox.ac.uk

Academic Positions

Associate Professor, University of Oxford Mathematical Institute Member of the Mathematical & Computational Finance Group Member of the Data Science Group	July 2020-
Assistant Professor, University of Illinois at Urbana-Champaign College of Engineering Department of Industrial & Enterprise Systems Engineering Coordinated Science Lab (Signals, Inference, & Networks group)	Aug. 2016-
Chapman Fellow, Imperial College London Department of Mathematics	2015-2016

Education

Stanford University, PhD	2010-2015
Princeton University, B.S.E. Graduated <i>summa cum laude</i> Elected to Phi Beta Kappa, Tau Beta Pi, and Sigma Xi	2006-2010

Research Interests

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

Research Publications

1. “Mean Field Analysis of Deep Neural Networks” (with K. Spiliopoulos).
Mathematics of Operations Research, 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).
Stochastic Systems, In Press, arXiv:1911.07304, 2019.
6. “Inference for Large Financial Systems” (with G. Schwenkler and K. Giesecke).
Mathematical Finance, 30 (1), 3-46, 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, 2016.
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). *Physical Review of Fluids*, 2020.
17. “Online Adjoint Methods for Optimization of Partial Differential Equations” (with K. Spiliopoulos). arXiv:2101.09621, 2021.
18. “PDE-constrained Models with Neural Network Terms: Optimization and Global Convergence” (with J. MacArt and K. Spiliopoulos). arXiv:2105.08633, 2021.
19. “Global Convergence of the ODE Limit for Online Actor-Critic Algorithms in Reinforcement Learning” (with Z. Wang). Submitted to NeurIPS, 2021.

Research Publications in Preparation

1. “ODE Limit of Actor-Critic Algorithms with Neural Networks” (with Z. Wang).
2. “Deep Learning Closure Models for Partial Differential Equations” (with J. MacArt).
3. “Reinforcement Learning with Order Book Data” (with X. Dong).
4. “Machine Learning Models for Pricing and Hedging Financial Derivatives” (with L. Fan).

Other Publications

1. “Optimization of Secondary-Air Addition in a Continuous One-Dimensional Spray Combustor” (with L. Rodriguez, A. Siders, and W. Sirignano). *Journal of Propulsion and Power*, 26(2), 288-294, 2010.
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. Workshop on Deep Learning and Partial Differential Equations, Isaac Newton Institute at the University of Cambridge, Invited Presentation, November 2021.
2. SIAM Conference on Financial Mathematics & Engineering, Invited Presentation, June 2021.
3. SIAM Conference on Applications of Dynamical Systems, Invited Presentation, June 2021.
4. Mathematical & Computational Finance seminar, University of Oxford, May 2021.
5. World Finance Seminar, May 2021.
6. Seminar at UCLA, Dept. of Mathematics, February 2021.
7. Seminar at University of Minnesota, Dept. of Mathematics, Fall 2021.
8. Seminar in Physics & Machine Learning, University of Oxford, November 2020.
9. Invited presentation at Maven Securities, London (virtual), October 2020.
10. NSF Workshop on *Machine Learning in Transport Phenomena* in Dallas, Texas, February 2020. Distinguished Speaker.
11. Two Sigma Investments, New York City, January 2020. Invited seminar.
12. Seminar at the University of Oxford, Dept. of Mathematics, October 2019. *Mathematical Finance* seminar.
13. Seminar at the University of Oxford, Dept. of Mathematics, October 2019. *Data Science* seminar.
14. Seminar at University of Michigan, Dept. of Mathematics, October 2019.
15. Colloquium at UCLA, Dept. of Mathematics, May 2019.
16. Workshop on Machine Learning at the University of Toronto, Fields Institute, September 2019. Invited Speaker.
17. Seminar at Carnegie Mellon University, Dept. of Statistics, January 2019.
18. Seminar at Columbia University, Dept. of Industrial Engineering & Operations Research, February 2019.
19. SIAM Financial Mathematics conference, June 2019.
20. SIAM Annual Meeting, July 2018.
21. London Quantitative Finance Seminar, May 2018.
22. Deep Learning Workshop, National Center for Supercomputing Applications, UIUC, October 2017.
23. Seminar at Princeton University, Dept. of Operations Research and Financial Engineering, 2017.
24. INFORMS Applied Probability Society Conference, Northwestern University, July 2017. Invited.
25. Seminar at Northwestern University, April 2017.
26. J.P. Morgan, New York City, August 2017. Invited seminar.

27. Seminar at UIUC Business School, February 2017.
28. SIAM Financial Mathematics Conference, Austin, Texas, November 2016. Co-organized minisymposium on machine learning in finance.
29. Bank of England, London, May 2016. Invited seminar.
30. INFORMS Annual Meeting, Nashville, November 2016. Invited.
31. Seminar at London Business School, London, June 2016.
32. Seminar at Oxford University, May 2016.
33. London-Paris Bachelier Workshop on Mathematical Finance, London, September 2015. Invited.
34. Lending Club, San Francisco, June 2015.
35. IPAM Workshop on Systemic Risk and Financial Networks, Los Angeles, 2015.
36. SIAM Financial Mathematics and Engineering Meeting, Chicago, 2014. Invited.
37. INFORMS Annual Meeting, San Francisco, 2014. Invited.
38. Joint Mathematics Meeting, Baltimore, 2014. Invited.
39. INFORMS Annual Meeting, Phoenix, October, 2012. Invited.
40. SIAM Financial Mathematics and Engineering Meeting, Minneapolis, 2012. Chair of the *Credit Risk* session.
41. Annual Meeting of the Canadian Applied and Industrial Mathematics Society, Toronto, 2012. Invited.
42. 5th Financial Risks International Forum, Paris, France, 2012.

Grants

1. Co-PI on \$16.5 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. Winner of the inaugural SIAM Financial Mathematics & Engineering Conference Paper Prize.
2. Award for being Ranked Excellent in Teaching for a graduate course on deep learning with two hundred enrolled students.
3. Distinguished Speaker at the NSF Workshop on *Machine Learning in Transport Phenomena* in Dallas, Texas, 2020.
4. Chapman Fellowship at Imperial College London
5. Rose Hills Foundation Engineering Fellowship at Stanford University.
6. 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.

Students

1. Ziheng Wang (Math, Oxford, 2024). PhD Thesis on mathematics of deep reinforcement learning.
2. Deqing Jiang (Math, Oxford, 2024). PhD Thesis on deep reinforcement learning and mathematical finance. (Co-advised with Professor Sam Cohen.)
3. Xiaobo Dong (ISE, UIUC, 2021). PhD Thesis: “Deep Reinforcement Learning Models of High Frequency Financial Data”.
4. Lei Fan (ISE, UIUC, 2021). PhD Thesis: “Machine Learning Methods for Pricing and Hedging Financial Derivatives”.
5. Abhinav (CS, UIUC, 2019). Masters Thesis: “Deep Learning Models of High Frequency Data”. (Now a PhD student at UIUC Computer Science.)
6. Yunxiang Zhang (Applied Math/CS/Stats, UIUC, 2018). Senior Thesis: “Multiscale Long Short-Term Memory for Limit Order Book.” (Now a PhD student at Cornell Operations Research & Information Engineering.)

Professional Activities

1. Associate Editor, *Mathematical Finance*.
2. Managing Editor, *Quantitative Finance*.
3. Associate Editor, *Journal of Dynamics and Games* (an AIMS journal).
4. Associate Editor, Special Issue of *Management Science* on Data-Driven Prescriptive Analytics.
5. Director of Masters program in Mathematical & Computational Finance at the University of Oxford.
 - Co-organized an internship program for students with banks, investment companies, and hedge funds. (Participating companies include Citadel, BNP Paribas, and EDF Trading.) The quantitative research conducted during the internship is part of the students’ MSc dissertations.
 - Organized the “Careers in Quantitative Finance” seminar series where companies present internship and job opportunities to the students. Participants in October-December, 2020 include Deutsche Bank, EDF Trading, Mazars, and NatWest Markets (formerly Royal Bank of Scotland).
 - Developed and taught a new course on deep learning.
 - Currently organizing a new Alumni Board and re-designing the introductory Python course.

6. Invited participant of 2021 research program “Mathematics of Deep Learning” at the Isaac Newton Institute for Mathematical Sciences” at the University of Cambridge.
7. 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.
8. Referee for *SIAM Journal on Applied Mathematics*, *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.

Other work experience

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

Citizenship

United States of America