Justin Sirignano

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Appointments

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
Management Science & Engineering

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

Research Interests

- Applied probability, stochastic analysis, limit theorems
- Asymptotic analysis of deep learning models
- Deep learning methods in scientific computing
- Computational methods, machine learning algorithms, and stochastic models in mathematical finance

Research Publications

1. "Mean Field Analysis of Neural Networks: A Law of Large Numbers" (with K. Spiliopoulos).
SIAM Journal on Applied Mathematics, forthcoming 2019.
2. "Mean Field Analysis of Neural Networks: A Central Limit Theorem" (with K. Spiliopoulos).
Stochastic Processes and their Applications, In Press, 2019.
3. "DGM: A Deep Learning Algorithm for solving Partial Differential Equations" (with K. Spiliopoulos).
Journal of Computational Physics, 375, 1339–1364, 2018.
4. "Stochastic Gradient Descent in Continuous Time: A Central Limit Theorem" (with K. Spiliopoulos).
Stochastic Systems, forthcoming 2019.
5. "Inference for Large Financial Systems" (with G. Schwenkler and K. Giesecke).
Mathematical Finance, forthcoming 2019.
6. "Stochastic Gradient Descent in Continuous Time" (with K. Spiliopoulos).
SIAM Journal on Financial Mathematics, 8(1), 933-961, 2017.

7. "Risk Analysis for Large Pools of Loans" (with K. Giesecke). **Winner of the inaugural SIAM Financial Mathematics & Engineering Conference Paper Prize.**
Management Science, 2018.

8. "Large-scale Loan Portfolio Selection" (with K. Giesecke and G. Tsoukalas).
Operations Research, 64(6), 1239-1255, 2016.

9. "Large Portfolio Asymptotics for Loss from Default" (with K. Giesecke, K. Spiliopoulos, and R. Sowers).
Mathematical Finance, 25(1), 77-114, 2015.

10. "Fluctuation Analysis for the Loss from Default" (with K. Giesecke and K. Spiliopoulos).
Stochastic Processes and their Applications, 124(7), 2322-2362, 2014.

11. "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.

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.
Invited revision at *Journal of Financial Econometrics*.

15. "Mean Field Analysis of Deep Neural Networks" (with K. Spiliopoulos). arXiv:1903.04440, 2019.
Invited Revision at *Mathematics of Operations Research*.

16. "Scaling Limit of Neural Networks with the Xavier Initialization and Convergence to a Global Minimum" (with K. Spiliopoulos). arXiv:1907.04108, 2019.

17. "Asymptotics of Deep Reinforcement Learning" (with K. Spiliopoulos). arXiv:1911.07304, 2019.

18. "DPM: A deep learning PDE augmentation method (with application to large-eddy simulation)" (with J. Freund and J. MacArt). arXiv:1911.09145, 2019.

Research Publications in Preparation

1. "A Large Deviation Principle for Neural Networks" (with K. Spiliopoulos).

2. "Deep learning closure models for turbulent combustion" (with J. Freund and J. MacArt).

3. "Deep Reinforcement Learning for Optimal Execution of Portfolio Transactions" (with X. Dong).

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 the University of Oxford, Dept. of Mathematics, October 2019. *Mathematical Finance* seminar.
2. Seminar at the University of Oxford, Dept. of Mathematics, October 2019. *Data Science* seminar.
3. Two Sigma Investments, New York City, January 2020. Invited seminar.
4. Seminar at Brown University, Dept. of Applied Mathematics, November 2019.
5. Seminar at University of Michigan, Dept. of Mathematics, October 2019.
6. Colloquium at UCLA, Dept. of Mathematics, May 2019.
7. NSF Workshop on *Machine Learning in Transport Phenomena* in Dallas, Texas, February 2020. Distinguished Speaker.
8. Seminar at University of Minnesota, Dept. of Mathematics, April 2020.
9. Workshop on Machine Learning at the University of Toronto, Fields Institute, September 2019. Invited Speaker.
10. SIAM Conference on Analysis of Partial Differential Equations, La Quinta CA, December 2019. Invited Talk.
11. Seminar at Carnegie Mellon University, Dept. of Statistics, January 2019.
12. Seminar at Columbia University, Dept. of Industrial Engineering & Operations Research, February 2019.
13. SIAM Financial Mathematics conference, June 2019.
14. SIAM Annual Meeting, July 2018.
15. London Quantitative Finance Seminar, May 2018.
16. Deep Learning Workshop, National Center for Supercomputing Applications, UIUC, October 2017.
17. Seminar at Princeton University, Dept. of Operations Research and Financial Engineering, 2017.
18. INFORMS Applied Probability Society Conference, Northwestern University, July 2017. Invited.
19. Seminar at Northwestern University, April 2017.
20. J.P. Morgan, New York City, August 2017. Invited seminar.
21. Seminar at UIUC Business School, February 2017.
22. SIAM Financial Mathematics Conference, Austin, Texas, November 2016. Co-organized minisymposium on machine learning in finance.
23. Bank of England, London, May 2016. Invited seminar.
24. INFORMS Annual Meeting, Nashville, November 2016. Invited.
25. Seminar at London Business School, London, June 2016.
26. Seminar at Oxford University, May 2016.
27. London-Paris Bachelier Workshop on Mathematical Finance, London, September 2015. Invited.
28. Lending Club, San Francisco, June 2015.
29. IPAM Workshop on Systemic Risk and Financial Networks, Los Angeles, 2015.

30. SIAM Financial Mathematics and Engineering Meeting, Chicago, 2014. Invited.
31. INFORMS Annual Meeting, San Francisco, 2014. Invited.
32. Joint Mathematics Meeting, Baltimore, 2014. Invited.
33. INFORMS Annual Meeting, Phoenix, October, 2012. Invited.
34. SIAM Financial Mathematics and Engineering Meeting, Minneapolis, 2012. Chair of the *Credit Risk* session.
35. Annual Meeting of the Canadian Applied and Industrial Mathematics Society, Toronto, 2012. Invited.
36. 5th Financial Risks International Forum, Paris, France, 2012.

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.

Computational Grants on the Blue Waters national supercomputer

1. Blue Waters Director's allocation (75,000 node hours, 2019)
2. Blue Waters general allocation (58,000 node hours, 2019)
3. Blue Waters general allocation (115,000 node hours, 2017-2018)
4. Blue Waters general allocation (111,000 node hours, 2016-2017)
5. Blue Waters startup allocation "Deep Learning: Modeling Financial Data and Reinforcement Learning" (25,000 node hours, 2016)
6. Blue Waters education allocation (100,000 node hours, 2019)
7. Blue Waters education allocation (50,000 node hours, 2018)
8. Blue Waters education allocation (50,000 node hours, 2017)
9. Blue Waters education allocation (25,000 node hours, 2016)

Teaching

1. "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.
2. "Deep Learning" (Spring 2018, 2019). Undergraduate course.
3. "Deep Learning II" (Spring 2018). Graduate course.
4. "Analysis of Data" (Spring 2017, Spring 2018). Undergraduate course.
5. "Machine Learning" (Spring 2016, Imperial College London, Dept. of Mathematics). Graduate course.

Current Students

1. Xiaobo Dong (ISE, 2022). PhD Thesis: "Deep Learning Models of High Frequency Financial Data".
2. Lei Fan (ISE, 2022). PhD Thesis: "Machine Learning Methods in Quantitative Finance".
3. Yite Wang (ME, 2022). PhD Thesis: "Deep learning closure models for PDEs".
4. Rachneet Kaur (ISE): PhD student collaborating on a machine learning project.
5. Abhinav (CS, 2019). Masters Thesis: "Deep Learning Models of High Frequency Data ".

Submitted Grant Proposals (currently under review)

1. NSF, NSF Career (DMS), Navy Young Investigator (Machine Learning program), Supercomputer grant (1 million node hours)
2. DoE/NNSA PSAAP III center (approximately $17 million, I am a co-PI). We are currently a **finalist** and DoE/NNSA is visiting UIUC in October. I am leading the machine learning part of this proposal.

Patents

1. US Patent Application 15/331,825
   Title: Apparatus for Analyzing the Risk of a Large Loan Pool and Method of Using
   Inventors: K. Giesecke and J. Sirignano
2. US Patent Application 15/613,256
   Title: Apparatus for Optimizing a Loan Pool and Method of Using
   Inventors: K. Giesecke and J. Sirignano

Professional Activities

1. Organizer of 2020 SIAM Workshop on "Mathematics of Deep Learning" (I wrote a proposal which was approved for $\$10,000$ in funding).
2. Associate Editor, *Mathematical Finance*.
3. Managing Editor, *Quantitative Finance*.
4. Associate Editor, *Journal of Dynamics and Games* (an AIMS journal).
5. Invited participant of proposed research program "Mathematics of Deep Learning" at the Isaac Newton Institute for Mathematical Sciences" at the University of Cambridge.
6. Associate Editor, Special Issue of *Management Science* on Data-Driven Prescriptive Analytics.
7. Organized Minisymposiums and Sessions
   (i) *Machine learning* minisymposium at SIAM Financial Math Meeting, Toronto, June 2018. 12 speakers.
   (ii) *Machine learning in finance* session at INFORMS Annual Meeting, Houston, October 2017.
   (iii) *Financial engineering* session at INFORMS Applied Probability Meeting, Northwestern University, July 2017.
   (iv) *Machine learning for finance* minisymposium at SIAM Financial Mathematics Conference, Austin, November 2016.
   (v) *Machine learning for finance* session at INFORMS Annual Meeting, Nashville, November 2016.
   (vi) *Large-scale portfolio risk* session at INFORMS Annual Meeting, Philadelphia, November 2015.

8. 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.

9. Member of committee for the Masters of Financial Engineering program.

10. 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