# Jiequn Han

Center for Computational Mathematics
Flatiron Institute
162 5th Avenue
New York, NY 10010

Email: jhan@flatironinstitute.org
Homepage: https://users.flatironinstitute.org/~jhan/

## Position

Flatiron Research Fellow, Center for Computational Mathematics, Flatiron Institute, 2021–present

Instructor of Mathematics, Department of Mathematics, Princeton University, 2018–2021

## Education

Ph.D. Applied Mathematics, Princeton University, USA, 2013–2018

B.S. Major in Mathematics and Minor in Economics, Peking University, China, 2009–2013

## Research Interests

Learning-based algorithms for scientific computing

Numerical methods for stochastic control and partial differential equations

Many-body problem in computational physics & chemistry

Mathematical finance, multi-agent system and mean field game theory

## Refereed Publications

1. X.-H. Zhou, J. Han, and H. Xiao, Frame-independent vector-cloud neural network for nonlocal constitutive modelling on arbitrary grids, *arXiv:2103.06685*, accepted by *Computer Methods in Applied Mechanics and Engineering*, in press.

2. M. Zhou, J. Han, and J. Lu, Actor-critic method for high dimensional static Hamilton–Jacobi–Bellman partial differential equations based on neural networks, *arXiv:2102.11379*, accepted by *SIAM Journal on Scientific Computing*, in press.

3. Y. Xuan, R. Balkin, J. Han, R. Hu, and H. D. Ceniceros, Optimal policies for a pandemic: A stochastic game approach and a deep learning algorithm, *arXiv:2012.06745*, accepted by *Mathematical and Scientific Machine Learning Conference (MSML)*, in press.

4. J. Han and R. Hu, Recurrent neural networks for stochastic control problems with delay, *Mathematics of Control, Signals, and Systems* (2021).

5. W. Wang, J. Han, Z. Yang, and Z. Wang, Global convergence of policy gradient for linear-quadratic mean-field control/game in continuous time, *International Conference on Machine Learning (ICML)*, (2021).

6. X.-H. Zhou, J. Han, and H. Xiao, Learning nonlocal constitutive models with neural networks, *Computer Methods in Applied Mechanics and Engineering*, 384, 113927 (2021).

7. W. E, J. Han, and L. Zhang, Machine-learning-assisted modeling, *Physics Today*, 74, 7, 36 (2021).

8. Z. Li, J. Han, W. E, and Q. Li, On the curse of memory in recurrent neural networks: approximation and optimization analysis, *International Conference on Learning Representations (ICLR)*, (2021).

9. Y. Achdou, J. Han, J.M. Lasry, P.L. Lions, and B. Moll, Income and wealth distribution in macroeconomics: A continuous-time approach, *The Review of Economic Studies* (2021).

10. J.B. Scoggins, J. Han, and M. Massot, Machine learning moment closures for accurate and efficient simulation of polydisperse evaporating sprays, *AIAA Scitech 2021 Forum*, 1786 (2021).

11. J. Han, J. Lu, and M. Zhou, Solving high-dimensional eigenvalue problems using deep neural networks: A diffusion Monte Carlo like approach, *Journal of Computational Physics*, 423, 109792 (2020).

12. J. Han and R. Hu, Deep fictitious play for finding Markovian Nash equilibrium in multi-agent games, *Mathematical and Scientific Machine Learning Conference (MSML)*, (2020).

13. J. Han and J. Long, Convergence of the deep BSDE method for coupled FBSDEs, *Probability,Uncertainty and Quantitative Risk*, 5(1), 1-33 (2020).

14. J. Han, C. Ma, Z. Ma and W. E, Uniformly accurate machine learning-based hydrodynamic models for kinetic equations, *Proceedings of the National Academy of Sciences*, 116(44) 21983-21991 (2019).

15. J. Han, L. Zhang, and W. E, Solving many-electron Schrödinger equation using deep neural networks, *Journal of Computational Physics*, 399, 108929 (2019).

16. W. E, J. Han, and Q. Li, A mean-field optimal control formulation of deep learning, *Research in the Mathematical Sciences*, 6:10 (2019).

17. L. Zhang, J. Han, H. Wang, W. Saidi, R. Car, and W. E, End-to-end symmetry preserving inter-atomic potential energy model for finite and extended systems, *Conference on Neural Information Processing Systems (NeurIPS)*, (2018).

18. J. Han, A. Jentzen, and W. E, Solving high-dimensional partial differential equations using deep learning, *Proceedings of the National Academy of Sciences*, 115(34), 8505-8510 (2018).

19. L. Zhang, J. Han, H. Wang, R. Car, and W. E, DeePCG: constructing coarse-grained models via deep neural networks, *The Journal of Chemical Physics*, 149, 034101 (2018).

20. H. Wang, L. Zhang, J. Han, and W. E, DeePMD-kit: A deep learning package for many-body potential energy representation and molecular dynamics, *Computer Physics Communications*, 228, 178–184 (2018).

21. L. Zhang, J. Han, H. Wang, R. Car, and W. E, Deep Potential Molecular Dynamics: a scalable model with the accuracy of quantum mechanics, *Physical Review Letters*, 120(10), 143001 (2018).

22. J. Han, L. Zhang, R. Car, and W. E, Deep Potential: a general representation of a many-body potential energy surface, *Communications in Computational Physics*, 23, 629–639 (2018).

23. W. E, J. Han, and A. Jentzen, Deep learning-based numerical methods for high-dimensional parabolic partial differential equations and backward stochastic differential equations, *Communications in Mathematics and Statistics* 5, 349–380 (2017).

24. J. Han and W. E, Deep learning approximation for stochastic control problems, Deep Reinforcement Learning Workshop, *Conference on Neural Information Processing Systems (NIPS)*, (2016).

25. J. Han, Y. Luo, W. Wang, P. Zhang, and Z. Zhang, From microscopic theory to macroscopic theory: a systematic study on modeling for liquid crystals, *Archive for Rational Mechanics and Analysis*, 215(3), 741–809 (2015).

## Preprints

1. J. Han, R. Hu, and J. Long, A class of dimensionality-free metrics for the convergence of empirical measures, *arXiv:2104.12036*.
2. J. Long, J. Han, and W. E, An $L^2$ analysis of reinforcement learning in high dimensions with kernel and neural network approximation, *arXiv:2104.07794*.
3. W. E, J. Han, and A. Jentzen, Algorithms for solving high dimensional PDEs: from nonlinear Monte Carlo to machine learning, *arXiv:2008.13333*.
4. J. Han, R. Hu, and J. Long, Convergence of deep fictitious play for stochastic differential games, *arXiv:2008.05519*.
5. X. Guo, J. Han, and W. Tang, Perturbed gradient descent with occupation time, *arXiv:2005.04507*.
6. J. Han, Y. Li, L. Lin, J. Lu, J. Zhang, and L. Zhang, Universal approximation of symmetric and anti-symmetric functions, *arXiv:1912.01765*.

## Seminar Talks

Stochastic Seminar, Brandenburg University of Technology (virtual), Jul. 2021

Control and Optimization Seminar, University of Connecticut (virtual), Apr. 2021

Mathematics in Imaging, Data and Optimization Seminar, Rensselaer Polytechnic Institute (virtual), Mar. 2021

CMSE Seminar, Michigan State University (virtual), Mar. 2021

CSE Seminar, Georgia Institute of Technology (virtual), Jan. 2021

Probability Seminar, University of Duisburg-Essen (virtual), Dec. 2020

Seminar on Stochastic Analysis, Statistics and Machine Learning, Linnaeus University (virtual), Nov. 2020

Applied Math Seminar, University of Georgia (virtual), Nov. 2020

Applied Mathematics Seminar, UC Berkeley/Lawrence Berkeley Laboratory (virtual), Nov. 2020

Applied Mathematics/PDE Seminar, UC Santa Barbara (virtual), Nov. 2020

Applied & Computational Mathematics Seminar, National University of Singapore, Singapore, Jan. 2020

PACM Colloquium, Princeton University, Princeton, Nov. 2019

Clements Scientific Computing Seminar, Southern Methodist University, Dallas, Sep. 2019

Applied Mathematics Seminar, UC Berkeley/Lawrence Berkeley Laboratory, Berkley, Sep. 2019

LSEC Seminar, Chinese Academy of Sciences, Beijing, China, Jul. 2019

Mathematics in Interaction with Computer Science Seminar, CentraleSupélec, Palaiseau, France, Jun. 2019

Applied Math Seminar, Center for Applied Mathematics, École Polytechnique, Gif-sur-Yvette, France, Jun. 2019

Smith Colloquium in Department of Mathematics, University of Kansas, Lawrence, May 2019

Financial Mathematics Seminar, University of Michigan, Ann Arbor, Mar. 2019

Applied Math & Analysis Seminar, Duke University, Durham, Oct. 2018

LSEC Seminar, Chinese Academy of Sciences, Beijing, China, Aug. 2018

Computational and Applied Math Seminar, Peking University, Beijing, China, Jul. 2018

## Conference Presentations

SIAM Minisymposium on Numerical Methods and Deep Learning for Nonlinear PDEs, SIAM SEAS21 (virtual), Sep 2021

Workshop on Machine Learning and Scientific Computing, Tianyuan Mathematical Center in Central China (virtual), Aug. 2021

Minisymposium on Probabilistic Methods for Systems Identification Under Uncertainty, 16th U.S. National Congress on Computational Mechanics (virtual), July 2021

SIAM Minisymposium on the Intersection of Optimal Control and Machine Learning, SIAM CT21 (virtual), July 2021

SIAM Minisymposium on Deep Learning for High-Dimensional Parametric PDEs, SIAM AN20 (virtual), July 2021

SIAM Minisymposium on Machine Learning for Interatomic Potentials, SIAM MS21 (virtual), May 2021

Miniworkshop: Analysis of Data-driven Optimal Control, Mathematical Research Institute of Oberwolfach (virtual), May 2021

SIAM Minisymposium on Physics Informed Learning for Modeling and Discovery of Complex Systems, SIAM CSE21 (virtual), Mar. 2021

Frontiers in Computing + Mathematical Sciences, California Institute of Technology (virtual), Jan. 2021

Session on the Intersection of Machine Learning, Control and Games, INFORMS 2020 (virtual), Nov. 2020

Workshop on Computation and Applications of PDEs Based on Machine Learning, Tianyuan Mathematical Center in Northeast China (virtual), Jul. 2020

SIAM Minisymposium on the Intersection of Optimal Control and Machine Learning, SIAM AN20 (virtual), Jul. 2020

SIAM Minisymposium on Mathematical Issues of Machine Learning, SIAM MDS20 (virtual), Jun. 2020

SIAM Minisymposium on Applications of Machine Learning to the Analysis of Nonlinear Dynamical Systems, JMM 2020, Denver, Jan. 2020

Session on From Stochastic Control to Data-Driven Decision Making, INFORMS 2019, Seattle, Oct. 2019

AIM Workshop on Deep Learning and Partial Differential Equations, San Jose, Oct. 2019

The 2nd National Congress of Big Data and Artificial Intelligence, Kunming, China, Jul. 2019

Computational Mathematics for Model Reduction and Predictive Modelling in Molecular and Complex Systems, EPFL, Lausanne, Switzerland, May 2019

Dimension Reduction in Physical and Data Sciences, Duke University, Durham, Apr. 2019

Minisymposium on Mathematical Advances in Deep Learning, SIAM CSE19, Spokane, Feb. 2019

AMS Special Session on Financial Mathematics, Baltimore, Jan. 2019

Mathematical Analysis and Computation for Quantum Systems, Peking University, Beijing, China, Jan. 2019

International Conference on Data Science, Fudan University, Shanghai, China, Dec. 2018

New Faculty Talks, Princeton University, Princeton, Oct. 2018

Machine Learning Theory Workshop, BICMR, Beijing, China, Jun. 2018

Stochastic Control, Computational Methods, and Applications, IMA, Minnesota, May 2018

Workshop on Learning, Modeling and Simulation, Princeton University, Princeton, Feb. 2018

Inverse Problems and Machine Learning, California Institute of Technology, Pasadena, Feb. 2018

## Experiences

Research Intern, Google DeepMind, UK, Jun.–Sep., 2017

REU Program, Mathematics Department, Pennsylvania State University, Jun.–Aug., 2011

## Service

Co-organizer (with Weinane E, Qi Gong, and Wei Kang), Minisymposium on the Intersection of Optimal Control and Machine Learning, SIAM CT21 (virtual), July 2021

Co-organizer (with Qi Gong and Wei Kang), Minisymposium on the Intersection of Optimal Control and Machine Learning, SIAM AN20 (virtual), July 2020

Referee for
SIAM J. Numer. Anal., SIAM J. Sci. Comput., SIAM J. Contr. Optim., J. Comput. Phys., J. Sci. Comput., Phys. Fluid, Comput. Methods Appl. Mech. Eng., Physica D, Commun. Math. Sci., Commun. Comput. Phys., Res. Math. Sci., NeurIPS, . J. Mach. Learn. Res., Neural. Comput., Math. Financ., among many others.

## Teaching

APC 350, Introduction to Differential Equations, Princeton University, Spring 2019, Spring 2020, Spring 2021

MAT 201, Multivariable Calculus, Princeton University, Fall 2018, Fall 2019, Fall 2020

Mathematical Introduction to Machine Learning, Applied Mathematics Summer School, Peking University, Aug 2018

## Honors and Awards

C.V. Starr Fellowship, Princeton University, 2014

Sumitomo Corporation Scholarship, Peking University, 2011

Academic Excellence Award, Peking University, 2011 & 2012

President Research Fund, Peking University, 2011–2012

Last updated: September, 2021