Wenrui Hao, Ph.D.

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Employment

Aug. 2016 – present	**Assistant professor**, Department of Mathematics, Penn State University, University Park, PA, USA
Aug. 2013 – Aug. 2016	**Postdoc fellow**, Mathematical Biosciences Institute, Ohio State University, Columbus, OH, USA.

Education

Aug. 2013	**Ph.D. in Applied Mathematics** University of Notre Dame, Notre Dame, IN, USA.
Jun. 2008	**M.S. in Computational Mathematics** Nankai University, Tianjin, China.
Jun. 2005	**B.S. in Applied Mathematics** University of Science & Technology Beijing, Beijing, China.

Research Grants

2021-2024	**National Science Foundation (DMS-2052685)**, Personalized modeling of Alzheimer's disease, $ 220,000 (PI at Penn State, a collaborative project with J. Petrella at Duke with a total budget $ 445,000).
2019-2020	**AiCure research grant**, Efficient training algorithms development for action detection & recognition, $ 73,450 (Single PI).
2018-2021	**National Science Foundation (DMS-1818769)**, Homotopy methods for computing bifurcations and multiple solutions of nonlinear PDEs with biological applications, $ 128,408 (Single PI).
2017-2021	**American Heart Association Scientist Development Grant (17SDG33660722)**, Personalized diagnosis and prediction of atherosclerotic aneurysms via computational models, $ 231,000 (Single PI).
2017-2018	**The Institute for CyberScience Seed Grant Program**, Predicting glucose level using cardiovascular activities through deep learning techniques, $ 25,000 (PI with X. Gao and J. Xu).

Publications

Journal Articles

1 Hao, W. (2021). A gradient descent method for solving a system of nonlinear equations. *Applied Mathematics Letters*, *112*, 106739.

2 Hao, W., Lam, K.-Y., & Lou, Y. (2021). Ecological and evolutionary dynamics in advective environments: Critical domain size and boundary conditions. *Discrete & Continuous Dynamical Systems-B*, *26*(1), 367.

3 Hao, W., Sun, P., Xu, J., & Zhang, L. (2021). Multiscale and monolithic arbitrary lagrangian–eulerian finite element method for a hemodynamic fluid-structure interaction problem involving aneurysms. *Journal of Computational Physics*, *433*, 110181.

4 Hao, W., & Zheng, C. (2021). A stochastic homotopy tracking algorithm for parametric systems of nonlinear equations. *Journal of Scientific Computing*, *87*(3), 1–14.

5 Ke, G., Hans, C., Agarwal, G., Orion, K., Go, M., & Hao, W. (2021). Mathematical model of atherosclerotic aneurysm. *Mathematical Biosciences and Engineering: MBE*, *18*(2), 1465–1484.

6 Zhao, X. E., Hao, W., & Hu, B. (2021). Convergence analysis of neural networks for solving a free boundary problem. *Computers & Mathematics with Applications*, *93*, 144–155.

7 Chen, J., Huang, H., Hao, W., & Xu, J. (2020). A machine learning method correlating pulse pressure wave data with pregnancy. *International journal for numerical methods in biomedical engineering*, *36*(1), e3272.

8 Hao, W., Hesthaven, J., Lin, G., & Zheng, B. (2020). A homotopy method with adaptive basis selection for computing multiple solutions of differential equations. *Journal of Scientific Computing*, *82*(1), 1–17.

9 Hao, W., & Xue, C. (2020). Spatial pattern formation in reaction–diffusion models: A computational approach. *Journal of mathematical biology*, *80*(1), 521–543.

10 Hao, W., & Zheng, C. (2020a). An adaptive homotopy method for computing bifurcations of nonlinear parametric systems. *Journal of Scientific Computing*, *82*(3), 1–19.

11 Hao, W., & Zheng, C. (2020b). Bifurcation analysis of a free boundary model of the atherosclerotic plaque formation associated with the cholesterol ratio. *Chaos: An Interdisciplinary Journal of Nonlinear Science*, *30*(9), 093113.

12 Karagiannis, G., Hao, W., & Lin, G. (2020). Calibrations and validations of biological models with an application on the renal fibrosis. *International journal for numerical methods in biomedical engineering*, *36*(5), e3329.

13 Chen, Q., & Hao, W. (2019). A homotopy training algorithm for fully connected neural networks. *Proceedings of the Royal Society A*, *475*(2231), 20190662.

14 Hao, W., Lam, K.-Y., & Lou, Y. (2019). Concentration phenomena in an integro-pde model for evolution of conditional dispersal. *Indiana University mathematics journal*, *68*.

15 Hao, W., & Yang, Y. (2019). Convergence of a homotopy finite element method for computing steady states of burgers' equation. *ESAIM: Mathematical Modelling and Numerical Analysis*, *53*(5), 1629–1644.

16 Petrella, J. R., Hao, W., Rao, A., & Doraiswamy, P. M. (2019). Computational causal modeling of the dynamic biomarker cascade in alzheimer's disease. *Computational and mathematical methods in medicine*, *2019*.

17 Friedman, A., & Hao, W. (2018). The role of exosomes in pancreatic cancer microenvironment. *Bulletin of mathematical biology*, *80*(5), 1111–1133.

18 Hao, W. (2018). A homotopy method for parameter estimation of nonlinear differential equations with multiple optima. *Journal of Scientific Computing*, *74*(3), 1314–1324.

19 Hao, W., & Harlim, J. (2018). An equation-by-equation method for solving the multidimensional moment constrained maximum entropy problem. *Communications in Applied Mathematics and Computational Science*, *13*(2), 189–214.

20 Hao, W., Hu, B., Li, S., & Song, L. (2018). Convergence of boundary integral method for a free boundary system. *Journal of Computational and Applied Mathematics*, *334*, 128–157.

21 Wang, Y., Hao, W., & Lin, G. (2018). Two-level spectral methods for nonlinear elliptic equations with multiple solutions. *SIAM Journal on Scientific Computing*, *40*(4), B1180–B1205.

22 Brake, D. A., Bates, D. J., Hao, W., Hauenstein, J. D., Sommese, A. J., & Wampler, C. W. (2017). Algorithm 976: Bertini_real: Numerical decomposition of real algebraic curves and surfaces. *ACM Transactions on Mathematical Software (TOMS)*, *44*(1), 1–30.

23 Friedman, A., & Hao, W. (2017). Mathematical modeling of liver fibrosis. *Mathematical Biosciences & Engineering*, *14*(1), 143.

24 Golubitsky, M., Hao, W., Lam, K.-Y., & Lou, Y. (2017). Dimorphism by singularity theory in a model for river ecology. *Bulletin of mathematical biology*, *79*(5), 1051–1069.

25 Hao, W., Komar, H. M., Hart, P. A., Conwell, D. L., Lesinski, G. B., & Friedman, A. (2017). Mathematical model of chronic pancreatitis. *Proceedings of the National Academy of Sciences*, *114*(19), 5011–5016.

26 Hao, W., & Friedman, A. (2016). Mathematical model on alzheimer's disease. *BMC systems biology*, *10*(1), 1–18.

27 Hao, W., Schlesinger, L. S., & Friedman, A. (2016). Modeling granulomas in response to infection in the lung. *PLoS One*, *11*(3), e0148738.

28 Friedman, A., & Hao, W. (2015). A mathematical model of atherosclerosis with reverse cholesterol transport and associated risk factors. *Bulletin of mathematical biology*, *77*(5), 758–781.

29 Friedman, A., Hao, W., & Hu, B. (2015). A free boundary problem for steady small plaques in the artery and their stability. *Journal of Differential Equations*, *259*(4), 1227–1255.

30 Gainutdinov, A. M., Hao, W., Nepomechie, R. I., & Sommese, A. J. (2015). Counting solutions of the bethe equations of the quantum group invariant open xxz chain at roots of unity. *Journal of Physics A: Mathematical and Theoretical*, *48*(49), 494003.

31 Hao, W., Marsh, C., & Friedman, A. (2015). A mathematical model of idiopathic pulmonary fibrosis. *PLoS One*, *10*(9), e0135097.

32 Hao, W., Xu, Z., Liu, C., & Lin, G. (2015). A fictitious domain method with a hybrid cell model for simulating motion of cells in fluid flow. *Journal of Computational Physics*, *280*, 345–362.

33 Lindsay, A. E., Hao, W., & Sommese, A. J. (2015). Vibrations of thin plates with small clamped patches. *Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *471*(2184), 20150474.

34 Sturrock, M., Hao, W., Schwartzbaum, J., & Rempala, G. A. (2015). A mathematical model of pre-diagnostic glioma growth. *Journal of theoretical biology*, *380*, 299–308.

35 Hao, W., Crouser, E. D., & Friedman, A. (2014). Mathematical model of sarcoidosis. *Proceedings of the National Academy of Sciences*, *111*(45), 16065–16070.

36 Hao, W., & Friedman, A. (2014). The ldl-hdl profile determines the risk of atherosclerosis: A mathematical model. *PloS one*, *9*(3), e90497.

37 Hao, W., Hauenstein, J. D., Hu, B., & Sommese, A. J. (2014). A bootstrapping approach for computing multiple solutions of differential equations. *Journal of Computational and Applied Mathematics*, *258*, 181–190.

38 Hao, W., Nepomechie, R. I., & Sommese, A. J. (2014). Singular solutions, repeated roots and completeness for higher-spin chains. *Journal of Statistical Mechanics: Theory and Experiment*, *2014*(3), P03024.

39 Hao, W., Hauenstein, J. D., Hu, B., McCoy, T., & Sommese, A. J. (2013). Computing steady-state solutions for a free boundary problem modeling tumor growth by stokes equation. *Journal of Computational and Applied Mathematics*, *237*(1), 326–334.

40 Hao, W., Hauenstein, J. D., Shu, C.-W., Sommese, A. J., Xu, Z., & Zhang, Y.-T. (2013). A homotopy method based on weno schemes for solving steady state problems of hyperbolic conservation laws. *Journal of Computational Physics*, *250*, 332–346.

41 Hao, W., Hu, B., & Sommese, A. J. (2013). Cell cycle control and bifurcation for a free boundary problem modeling tissue growth. *Journal of Scientific Computing*, *56*(2), 350–365.

42 Hao, W., Nepomechie, R. I., & Sommese, A. J. (2013). Completeness of solutions of bethe's equations. *Physical Review E*, *88*(5), 052113.

43 Hao, W., Sommese, A. J., & Zeng, Z. (2013). Algorithm 931: An algorithm and software for computing multiplicity structures at zeros of nonlinear systems. *ACM Transactions on Mathematical Software (TOMS)*, *40*(1), 1–16.

44 Hao, W., & Zhu, S. (2013). Domain decomposition schemes with high-order accuracy and unconditional stability. *Applied mathematics and computation*, *219*(11), 6170–6181.

45 Hao, W., Hauenstein, J. D., Hu, B., Liu, Y., Sommese, A. J., & Zhang, Y.-T. (2012a). Bifurcation for a free boundary problem modeling the growth of a tumor with a necrotic core. *Nonlinear Analysis: Real World Applications*, *13*(2), 694–709.

46 Hao, W., Hauenstein, J. D., Hu, B., Liu, Y., Sommese, A. J., & Zhang, Y.-T. (2012b). Continuation along bifurcation branches for a tumor model with a necrotic core. *Journal of Scientific Computing*, *53*(2), 395–413.

47 Hao, W., Hauenstein, J. D., Hu, B., Liu, Y., Sommese, A. J., & Zhang, Y.-T. (2011). Multiple stable steady states of a reaction-diffusion model on zebrafish dorsal-ventral patterning. *Discrete and Continuous Dynamical Systems-Series S*, *4*(6), 1413–1428.

48 Hao, W., Hauenstein, J. D., Hu, B., & Sommese, A. J. (2011). A three-dimensional steady-state tumor system. *Applied Mathematics and Computation*, *218*(6), 2661–2669.

Books and Chapters

1 Hao, W., Hu, B., & Sommese, A. J. (2014). Numerical algebraic geometry and differential equations. In *Future vision and trends on shapes, geometry and algebra* (pp. 39–53). Springer.

Advising

Dr. Chuanbin Li	Postdoc researcher, 2017 Aug.-2019 Dec. First job: software engineer at Google.
Dr. Qipin Chen	Ph.D., Penn State University, Graduated in 2020 Dec. First job: software engineer at Amazon.
Ms. Chunyue Zheng	Ph.D. student, Penn State University, 2017 Aug. – now.
Mr. Yushuang Luo	Ph.D. student, Penn State University, 2018 May – now (Co-advise with Prof. Xiantao Li).
Mr. David Bromberg	Undergraduate student, Penn State University, 2020 Sep. – 2021 May. He is in the MBA program at the Wharton school of the University of Pennsylvania.
Mr. Heming Liu	Undergraduate student, Penn State University, 2019 Summer. He is a graduate student of Department of Statistics at University of Chicago.
Ms. Yao Xiao	Undergraduate student, Penn State University, 2017 Summer. She is a graduate student of School of Computer Science at Carnegie Mellon University.
Mr. Yifan Chen	Undergraduate student, Penn State University, 2017 Summer (Supported by the Office of Science Engagement). He is a graduate student of Smeal College of Business at Penn State.
Mr. Arazi Lubis	Undergraduate student, Penn State University, 2017 Summer.

Invited Presentations

1 Computational models of cardiovascular disease. (2021). 2021 SMB annual meeting, Jun.

2 Computational models of cardiovascular disease. (2021). UMss Amherst, Mathematical and Computational Biology Seminar, May.

3 Numerical methods for solving nonlinear PDEs from homotopy methods to machine learning. (2021). University of South Carolina, Applied and Computational Mathematics Seminar, Feb.

4 Numerical methods for solving nonlinear PDEs from homotopy methods to machine learning. (2021). The City College of New York, Mathematics Colloquium, Feb.

5 Homotopy training algorithm for neural networks and applications in pattern formation. (2021). Sanya Workshop on Algebraic Geometry and Machine Learning, Jan.

6 Nonlinear scientific computing in machine learning and applications. (2020). Seminar on Optimization and Data Science, University of California San Diego, November, Nov.

7 A Randomized Newton's Method For Solving Differential Equations Based On The Neural Network Discretization. (2020). 3rd Annual Meeting of the SIAM Texas-Louisiana Sectional Conference, Texas A&M University, Oct.

8 Nonlinear computation in neural networks. (2020). AMS Fall Eastern Sectional Meeting, Penn State, Oct.

9 Nonlinear scientific computing in machine learning and applications. (2020). Department of Mathematics Colloquium, University of Manitoba, Canada, Oct.

10 Numerical methods for solving nonlinear PDEs from homotopy methods to machine learning. (2020). Applied and Computational Mathematics Seminar, Georgia Tech, Oct.

11 A homotopy training algorithm for fully connected neural networks. (2020). Special Session on Algebraic Geometry and Machine Learning, SIAM Conference on Mathematics of Data Science, Jul.

12 Reaction-diffusion equations in biology: from pattern formation to Alzheimer's disease. (2020). Applied Math seminar, Illinois Institute of Technology, Jul.

13 Computational methods for solving nonlinear systems arising from biology. (2020). Mathematical and Computational Methods in Biology, Mathematical Biosciences Institute, May.

14 Computational modeling of cardiovascular disease. (2019). Applied math colloquium, Illinois Institute of Technology, Nov.

15 Computational modeling of cardiovascular disease. (2019). Conference on Computational Mathematics and Applications, Las Vegas, Oct.

16 Homotopy methods for solving nonlinear systems and beyond. (2019). Applied math seminar, University of Alabama, Oct.

17 Homotopy methods for solving nonlinear systems and beyond. (2019). The Third Conference on Scientific and Engineering Computing for Young Chinese Scientists, Aug.

18 Harness computational modeling to biomedical data. (2019). Computational Modeling and Image Processing of Biomedical Problems, Michigan Technological University, Jun.

19 Homotopy methods for nonlinear systems from PDE to machine learning. (2019). Computational math colloquium, Purdue University, Mar.

20 Computational modeling of cardiovascular disease. (2018). Applied math seminar, Michigan State University, Nov.

21 Mathematical Modeling for Chronic Disease Research. (2018). Harnessing Big Data Science for Nutrition and Chronic Disease Discoveries, Penn State Nutrient Department, Nov.

22 Computational modeling of cardiovascular disease. (2018). SIAM Conference on Life Sciences, Minneapolis, Aug.

23 Bifurcations arising from a generalized Hele-Shaw problem. (2018). Numerical Analysis of Coupled and Multi-Physics Problems with Dynamic Interfaces, Oaxaca, Jul.

24 Harness computational modeling to evaluate personalized cardiovascular risk. (2018). American Heart Association public breakfast, Jun.

25 Mathematical modeling of Alzheimer's disease. (2018). NSF-CBMS Regional Conference on Mathematical Biology, Washington DC, May.

26 Reduced Basis Homotopy Method for Computing Multiple Solutions of Nonlinear PDEs. (2017). SIAM Conference on Applied Algebraic Geometry, Atlanta, Georgia, Aug.

27 Computational modeling for cardiovascular disease. (2017). University of Dealware, May.

28 Mathematical modeling for vascular diseases. (2016). IUPUI, Mar.

29 Numerical methods for nonlinear systems and biological applications. (2016). Wright State, Mar.

30 Numerical methods for parameter investigations in nonlinear systems. (2016). Penn State, Mar.

31 Mathematical modeling for vascular diseases. (2016). University of Florida, Feb.

32 Parameter investigations in biological systems. (2016). Hongkong University, Jan.

33 Mathematical modeling for vascular diseases. (2015). Louisiana University, Dec.

34 Mathematical modeling for vascular diseases. (2015). Virginia Tech, Nov.

35 Fictitious Domain Method with a Hybrid Cell Model for Simulating Motion of Cells in Fluid Flow. (2015). ICIAM, Aug.

36 Homotopy continuation methods for nonlinear PDEs and applications. (2015). University of Maryland, College Park, Apr.

37 Homotopy continuation methods for nonlinear PDEs and applications. (2015). University of Maryland, College Park, Feb.

38 Fictitious Domain Method with a Hybrid Cell Model for Simulating Motion of Cells in Fluid Flow. (2014). 2014 SIAM Annual Meeting.

39 Parameter investigation and biological systems. (2014). ICERM, Brown University, Jun.

40 Homotopy Method and biological applications. (2014). 2014 AMS JMM.

41 Homotopy Method and Nonlinear PDEs. (2013). UC Irvine applied math. seminar, Sep.

42 Applications of Homotopy Method to Nonlinear PDEs. (2013). SIAM Conference on Applied Algebraic Geometry, Aug.

43 MULTIPLICITY: A software for computing multiplicity structures at zeros of nonlinear systems. (2013). Symbolic Computation Seminar, NC State University, Apr.

44 Numerical methods for nonlinear PDEs with biological applications. (2013). Applied Math Seminar, Colorado State University, Mar.

45 Numerical methods for nonlinear PDEs with biological applications. (2013). Math. Colloquium, Michigan Technological University, Feb.

46 Numerical methods for nonlinear PDEs with biological applications. (2013). Math. Colloquium, Auburn University, Feb.

47 Cell cycle control and bifurcation for a free boundary problem modeling tissue growth. (2012). Numerical Algebraic Geometric Algorithms for Kinematics and PDE Applications, SIAM annual meeting, Jul.

48 Solve nonlinear PDE using numerical algebraic geometry. (2012). Midwest Numerical Analysis Days 2012, Notre Dame, May.

49 A numerical approach to solve tumor growth model with a free boundary. (2012). Illinois Institute of Technology, Feb.

50 Applications of numerical algebraic geometry to tumor growth. (2012). University of Alberta, Feb.

51 A Domain Decomposition Algorithm for Computing Multiple Steady States of Differential Equations. (2011). SIAM Conference on Applied Algebraic Geometry, Oct.

52 Computing steady-state solutions for a free boundary problem modeling tumor growth by stokes equation. (2011). The 2011 CNA fluids conference: Incompressible fluids, Turbulence and Mixing, Oct.

53 Homtopy continuation and tumor growth. (2010). 2010 AMS Fall Central Section Meeting, Nov.

Organized Conferences

1 Special Session on Nonlinear Scientific Computing and Applications. (2020), (AMS 2020 Fall Eastern Sectional Meeting, University Park, PA, Oct.).

2 Special Session on Numerical Methods for PDEs and Applications. (2019), (AMS 2019 Joint Mathematics Meetings, Baltimore, Maryland, Jan.).

3 Special Session on Nonlinear Systems and Applications. (2017), (AMS 2017 Joint Mathematics Meetings, Atlanta, Georgia, Jan.).

4 Special Session on PDE problems with moving and free boundaries. (2017), (2017 (14th) international conference on free boundary problems theory and applications, Shanghai, China, Jul.).

5 Special Session on Nonlinear Systems: polynomial equations, nonlinear PDEs and applications. (2014), (AMS 2014 Joint Mathematics Meetings, Baltimore, Maryland, Jan.).

6 Minisymposium on Applications of Numerical Algebraic Geometry. (2013), (SIAM Conference on Applied Algebraic Geometry, Colorado State University, Aug.).

Awards

2020 April **Donald C. Rung Award for Distinguished Undergraduate Teaching**, Penn State University.