Varun Shankar

Contact Information	50 S. Central Campus Drive MEB 3112 Salt Lake City, UT 84112, USA	*Voice:* (385) 259-8400 *E-mail:* shankar@cs.utah.edu *url:* http://www.varunshankar.com/

Research Interests Radial Basis Functions and other meshfree methods, numerical methods for PDEs on irregular domains and surfaces, machine learning for scientific computing.

Current Employment
Co-interim Director, Master of Software Development, University of Utah, **July 2022 - June 2023**.
Associate Director, Master of Software Development, University of Utah, **July 2022 - Present**.
Assistant Professor Lecturer, School of Computing, University of Utah, **July 2018 - Present**.
Adjunct Graduate Faculty, Dept. of Mathematics, Boise State University, **April 2019 - Present**.

Past Employment
Postdoctoral position, Dept. of Mathematics, University of Utah, **July 2014 - June 2018**.
Research Associate, Dept. of Mathematics, University of Utah, **May 2014 - June 2014**.
Graduate Research Assistant, School of Computing, University of Utah, **Jan 2010 - April 2014**.

Education

University of Utah, Salt Lake City, Utah USA, **2009-2014**

PhD. in Computing, Scientific Computing.

University of California, Davis, California USA, **Jan 2009-March 2009**

Visiting Scholar, SRM University Semester Abroad Program and UC Davis Global Study Program.

SRM University, Chennai, Tamil Nadu India, **2005-2009**

Bachelor of Technology, Computer Science and Engineering.

Awarded Grants

AFRL/NIAR. "Composite Repair and Modeling".
PI: Michael W. Czabaj
co-PI: Robert M. Kirby
co-PI: Varun Shankar
co-PI: Hari Sundar
Status: Approved, Spring 2021.
Amount: $250,000
Period: 2022–2024
Student outcomes: Will fund 1 SoC PhD student at 40%.

NSF CISE-CCF 1714844. "AF: Small: Collaborative: Scalable, high-order mesh-free algorithms applied to bulk-surface biomechanical problems".
Utah PI - Varun Shankar
Boise State PI - Grady B. Wright
PhD student: Andrew Jones (underrepresented group)
Total amount: $322,907
Utah amount: $88,619
Period: 2017–2022
Student outcomes: Funded Boise State's first PhD student.

NSF DMS-1521748. "The Best of Both: Toward a hybrid discrete and continuum multiscale platelet aggregation and coagulation model".
PI- Robert M. Kirby

co-PI - Aaron L. Fogelson
co-PI - Varun Shankar
Department of Mathematics PhD student: Andrew Kassen
School of Computing PhD student: Vidhi Zala (underrepresented group)
Amount: $450,000
Period: 2015–2020
Student outcomes: Funded 2 PhD students (one from SoC, one from Math).

Honors and Awards

- Nominated for School of Computing Outstanding Teacher award, 2022.
- College of Engineering Dean's teaching recognition, Fall 2020.
- College of Engineering Dean's teaching recognition, Fall 2019.
- NSF travel award for PNWNAS 2012.
- Bharat Petroleum Corporation Limited (BPCL) Scholarship for higher studies abroad (2010).
- TataChem Foundation Scholarship award for higher studies abroad (2009).
- SRM University Merit scholarship 2007-2008 for being in the top 2% of my batch.
- SRM University Merit scholarship 2006-2007 for being in the top 2% of my batch.

Publications

Google Scholar Page: `https://scholar.google.com/citations?user=goYJXTsAAAAJ&hl=en`

1. Mingxuan Han, Chenglong Ye, **Varun Shankar**, and Jeff Philips. Anonymous submission to AIStats 2023.
2. Ramansh Sharma and **Varun Shankar**. Accelerated training of physics-informed neural networks (PINNs) using Meshless Discretizations (NeurIPS 2022).
3. Grady B. Wright, Andrew M. Jones, and **Varun Shankar**. MGM: A meshfree geometric multilevel method for systems arising from elliptic equations on point cloud surfaces (Accepted to SIAM Journal on Scientific Computing (SISC), September 2022).
4. Keith M. Ballard, Endel Iarve, John Whitcomb, **Varun Shankar**, Hari Sundar, Lauren Ferguson, Robert M. Kirby, and David Mollenhauer. Remaining Challenges in the Application of High-Performance Computing to a Process-To-Performance Pipeline for Textile Composites (Proceedings of the American Society for Composites-Thirty-Seventh Technical Conference, September 2022).
5. Andrew Kassen, Aaron Barrett, **Varun Shankar**, and Aaron L. Fogelson. Immersed boundary simulations of cell-cell interactions in whole blood (Journal of Computational Physics, August 2022).
6. Andrew Kassen, **Varun Shankar**, and Aaron L. Fogelson. A fine-grained parallelization of the Immersed Boundary method (International Journal of High Performance Computing Applications (IJHPCA), June 2022).
7. Keith M. Ballard, Roman Amici, **Varun Shankar**, Lauren A. Ferguson, M. Braginsky, and Robert M. Kirby. Towards an Extrinsic, CG-XFEM approach based on hierarchical enrichments for modeling progressive fracture (Computer Methods in Applied Mechanics and Engineering (CMAME), January 2022).
8. **Varun Shankar**, Grady B. Wright, and Aaron Fogelson. An efficient high-order meshless method for advection-diffusion equations on time-varying irregular domains (Journal of Computational Physics, August 2021).
9. Hallie Elich, Aaron Barrett, **Varun Shankar**, Aaron L. Fogelson. Pump efficacy in a two-dimensional, fluid-structure-interaction model of a chain of contracting lymphangions (Biomechanics and Modeling in Mechanobiology, July 2021).
10. **Varun Shankar**, Grady B. Wright, and Akil Narayan. A Robust Hyperviscosity Formulation for Stable RBF-FD Discretizations of Advection-Diffusion-Reaction Equations on Manifolds (SIAM Journal on Scientific Computing, August 2020).

11. Sean Lawley and **Varun Shankar**. Asymptotic and numerical analysis of a stochastic PDE model of volume transmission (SIAM Multiscale Modeling and Simulation, May 2020).
12. Keith M. Ballard, Roman Amici, **Varun Shankar**, and Robert M. Kirby. A preliminary assessment of a new XFEM framework for predicting complex fracture (22nd International Conference on Composite Materials (ICCM22), August 2019).
13. **Varun Shankar** and Aaron L. Fogelson. Hyperviscosity-based Stabilization for Radial Basis Function-Finite Difference (RBF-FD) discretizations of advection-diffusion equations (Journal of Computational Physics, November 2018).
14. **Varun Shankar**, Akil Narayan, and Robert M. Kirby. RBF-LOI: Augmenting Radial Basis Functions (RBFs) with Least Orthogonal Interpolants (LOI) for Solving PDEs on Surfaces (Journal of Computational Physics, November 2018).
15. **Varun Shankar**, Aaron L. Fogelson and Robert M. Kirby. Robust Node Generation for Mesh-free Discretizations on Irregular Domains and Surfaces (SIAM Journal on Scientific Computing, August 2018).
16. **Varun Shankar** and Grady B. Wright. Mesh-free Semi-Lagrangian Methods for Advection on a Sphere using Radial Basis Functions (Journal of Computational Physics, August 2018).
17. Santosh Pokhrel, **Varun Shankar**, and Jamesina J. Simpson. 3-D FDTD Modeling of Electromagentic Wave Propagation in Magnetized Plasma Requiring Singular Updates to the Current Density Equation (IEEE Transactions on Antennas and Propagation, June 2018).
18. Vidhi Zala, **Varun Shankar**, Shankar P. Sastry, and Robert M. Kirby. Curvilinear Mesh Rectification using Radial Basis Function Interpolation and Smoothing (Journal of Scientific Computing, April 2018).
19. Santosh Pokhrel, **Varun Shankar**, and Jamesina J. Simpson. Simplified FDTD model of electromagnetic wave propagation in magnetized plasma (Applied Computational Electromagnetric Society Symposium [ACES], March 2018).
20. **Varun Shankar**. The Overlapped Radial Basis Function-Finite Difference (RBF-FD) Method: A Generalization of RBF-FD (Journal of Computational Physics, August 2017).
21. E. Lehto, **Varun Shankar** and Grady B. Wright. A Radial Basis Function (RBF)-Based Compact Finite Difference (FD) Scheme for Reaction-Diffusion Equations on Surfaces (SIAM Journal on Scientific Computing, September 2017).
22. Edward J. Fuselier, **Varun Shankar** and Grady B. Wright. A High-Order Radial Basis Function (RBF)-Based Leray Projection Method for the Incompressible Stokes Equations (Computers and Fluids, April 2016).
23. **Varun Shankar**, Grady B. Wright, Robert M. Kirby, and Aaron L. Fogelson. Augmenting the Immersed Boundary Method with Radial Basis Functions (RBFs) for the modeling of platelets in hemodynamic flows (Int. J. Numer. Meth. Fluids, July 2015).
24. **Varun Shankar** and Sarah D. Olson. Radial Basis Function (RBF)-Based Parametric Models for Open and Closed Curves within the Method of Regularized Stokeslets (Int. J. Numer. Meth. Fluids, May 2015).
25. **Varun Shankar**, Grady B. Wright, Robert M. Kirby, and Aaron L. Fogelson. A Radial Basis Function (RBF)-Finite Difference Method for Diffusion and Reaction-Diffusion Equations on surfaces (Journal of Scientific Computing, September 2014).
26. **Varun Shankar**, Grady B. Wright, Aaron L. Fogelson, and Robert M. Kirby. A Radial Basis Function (RBF)-Finite Difference Method for the Simulation of Reaction-Diffusion Equations on Stationary Platelets within the Augmented Forcing Method (Int. J. Numer. Meth. Fluids, January 2014).
27. **Varun Shankar**, Grady B. Wright, Aaron L. Fogelson, and Robert M. Kirby, A study of different modeling choices for simulating platelets within the immersed boundary method (Applied Numerical Mathematics, January 2013).

Papers in preparation

1. Ramansh Sharma and **Varun Shankar**. Federated Learning and Discrete Training for Physics-Informed Neural Networks (working title).
2. Ramansh Sharma and **Varun Shankar**. Federated Regression with Deep Neural Networks (working title).
3. Urban Duh, **Varun Shankar**, and Gregor Kosec. NURB-DIVG: Variable-density node generation on domains enclosed by NURB surfaces.
4. **Varun Shankar**. Stacked surface representations for variable-density Node generation on domains with piecewise-smooth boundaries.
5. **Varun Shankar**, Akil Narayan, and Gregory Fasshauer. A unified framework for kernel and polynomial approximation.
6. **Varun Shankar** and Robert M. Kirby. Shared memory Parallelization of the Overlapped Radial Basis Function-Finite Difference (RBF-FD) Method.

Service

1. Associate Director and co-interim director, Master of Software Development (MSD).
2. MSD industry seminar, Fall 2022.
3. MSD industry seminar, Spring 2022.
4. School of Computing (SoC) Grad Visit, Spring 2022.
5. SoC PhD recruiting event, Fall 2021.
6. SoC graduate admissions committee, 2021-2022.
7. MSD lab instruction/assistance, Fall 2021.
8. MSD capstone committee, Fall 2021.
9. MSD admissions committee, 2021-2022.
10. MSD steering committee, 2021-2022.
11. SoC Grad Visit committee, Spring 2021.
12. SoC lecturing faculty hiring committee, Spring and Summer 2021.
13. SoC graduate admissions committee, 2020-2021.
14. MSD steering committee, 2020-2021.
15. Hiring committee for Brent Stephens, Fall 2020.
16. MSD capstone committee, Fall 2020.
17. MSD admissions committee, 2020-2021.
18. Co-organizer of poster session for SoC Grad Visit, Spring 2020 (with Marina Kogan).
19. MSD steering committee 2019-2020.
20. MSD capstone committee, Fall 2019.
21. MSD admissions committee, 2019-2020.
22. School of Computing graduate admissions committee, 2019-2020.
23. MSD outreach: Silicon Slopes talks, booth. Fall 2018, Spring 2019.
24. MSD capstone committee, Fall 2018.

Reviewing Experience

Reviewed for

1. SIAM Journal on Scientific Computing (SISC).
2. Journal of Computational Physics (JCP).
3. International Journal for Numerical Methods in Engineering (IJNME).
4. Journal of Scientific Computing (JSC).
5. Applied Numerical Mathematics (APNUM).
6. Computers and Fluids.
7. Computers and Mathematics with Applications.
8. Engineering Analysis with Boundary Elements.
9. BIT Numerical Mathematics.

Teaching Experience

Instructor

MSD: Computer Programing (CS 6011), Fall 2022.
MSD: Introduction to Software Development (CS 6010), Fall 2022.
Mobile Application Programming (CS 4530), Spring 2022.
MSD: Data Structures and Algorithms (CS 6012), Fall 2021.
MSD: Application System Design (CS 6018), Fall 2021.
MSD: Systems I: Operating Systems and Computer Architecture (CS 6013), Spring 2021.
MSD: Data Structures and Algorithms (CS 6012), Fall 2020.
MSD: Application System Design (CS 6018), Fall 2020.
MSD: Database Systems (CS 6016), Summer 2020.
MSD: Systems I (CS 6013), Spring 2020.
MSD: Data Structures and Algorithms (CS 6012), Fall 2019.
MSD: Application System Design (CS 6018), Fall 2019.
MSD: Database Systems (CS 6016), Summer 2019.
Intro to Scientific and Data Computing (CS 3200), Spring 2019.
MSD: Data Structures and Algorithms (CS 6012), Fall 2018.
MSD: Application System Design (CS 6018), Fall 2018.
Numerical Analysis II (Math 5620/6865), Spring 2017.
Differential Equations and Linear Algebra (Math 2250), Fall 2016.
Numerical Analysis II (Math 5620/6865), Spring 2016.
Vector Calculus and PDEs for Engineers (Math 3140), Fall 2015.
Differential Equations and Linear Algebra (Math 2250), Spring 2015.
Engineering Calculus II (Math 1320), Fall 2014.

Teaching Assistant

Advanced Scientific Computing II, Spring 2014.
Advanced Scientific Computing I, Fall 2013.
Advanced Scientific Computing II, Spring 2013.
Advanced Scientific Computing I, Fall 2012.

Course Design

I was the first to teach and develop the course materials for CS 6018, Application System Design, which is the final course in the Master's in Software Development (MSD) program in the School of Computing, University of Utah. The course is focused on developing applications for Android devices, using this platform as a tool to teach good software design and engineering. Over Summer 2022, I updated this class to use Kotlin rather than Java to keep up with industry standards.

Over Spring 2020-2021, I updated CS 6013 (MSD) to incorporate GPU and multicore programming.

Math 5620/6865 required me to develop my own syllabus and course structure. I have developed a simple yet unifying technique for teaching Numerical Analysis of ODEs and PDEs, and my own typeset course materials. I've simplified this material, updated it to include numerical linear algebra and data science techniques, and adapted it to CS 3200.

MENTORING EXPERIENCE

I have mentored MSD capstone projects for all students in cohorts for 5 years.

Current research mentees are:

1. Ramansh Sharma, B.Tech. Student, Computer Science and Engineering, SRM Institute of Science and Technology, India.

Currently also on the committee for:

1. Mingxuan Han, PhD candidate, School of Computing (advised by Jeff Philips).
2. Keshav Patel, PhD candidate, Department of Mathematics (advised by Aaron L. Fogelson).

Former mentees are:

1. Dr. Andrew Jones, Department of Mathematics, Boise State University (co-advised with Grady B. Wright).
2. Dr. Andrew Kassen, Department of Mathematics (co-advised with Aaron L. Fogelson).
3. Dr. Hallie Elich, Department of Mathematics (co-advised with Aaron L. Fogelson).
4. Hannah Bruns, undergraduate thesis, SoC. UROP award recipient. Currently at BioFire.
5. Zixuan Zhao, MSD graduate, School of Computing. Hourly research assistant.
6. Roman Amici, MS student, School of Computing (co-advised with Robert M. Kirby).
7. Sage Shaw, MS student, Department of Mathematics, Boise State University (co-advised with Grady B. Wright). Currently PhD student at CU Boulder.
8. Daniel Malmuth, MS student, Department of Mathematics, Boise State University (co-advised with Grady B. Wright).
9. M.S. Srivatsa, M.S. in Computer Science, School of Computing (co-advised with Robert M. Kirby). Currently at Microsoft.
10. Harshitha Parnandi, M.S. in Computer Science, School of Computing (co-advised with Robert M. Kirby).
11. Dr. Vidhi Zala, during her M.S. in Computer Science, School of Computing (co-advised with Robert M. Kirby).

EXTERNAL ORGANIZATIONAL EXPERIENCE

1. Co-organizer (with Grady B. Wright) of the 2-part minisymposium titled "Recent advances in Kernel-based Meshless Methods" at the conference Approximation Theory 16, May 19-22, 2019. This minisymposium brought together leading theoreticians and practitioners in the world of meshless methods.
2. Head organizer for poster session, member of Local Organizing Committee, Society of Mathematical Biology Annual meeting (http://www.smg.org), University of Utah, July 17-20, 2017.
3. Co-organizer of the conference "Modeling Complex Fluids and Gels for Biological Applications", University of Utah, May 4-6, 2017. This conference brought together leading researchers in the field of complex biofluids.
4. Co-organizer (with Grady B. Wright) of the 5-part minisymposium titled "Advances in Radial Basis Function and Other Meshfree Methods", SIAM CSE 2015. This minisymposium had 20 of the top researchers in meshfree methods from across the world as speakers.

Conference Talks and Other Presentations

1. "Stacked surface representations for Geometric Modeling and Node Generation", SIAM Conference on Geometric and Physical Modeling, Session on Meshless Methods, September 2021. Invited by Grady Wright.
2. "A High-Order Meshless Semi-Lagrangian Method for PDEs on Surfaces", Dolomites Workshop on Constructive Approximation and Applications (dedicated to Robert Schaback on his 75^{th} birthday), Session on Meshless Methods, September 2021. Invited by Gabriele Santin and Emma Perrachione.
3. "A High-Order Meshless Semi-Lagrangian Method for PDEs on Surfaces", SIAM Conference on Mathematical and Computational Issues in the GeoSciences, Minisymposium on Approximation in Geosciences: Theory and Numerics, June 2021. Invited by Alessandra de Rossi and Francesco Dell'Accio.
4. "Case Studies in Scientific Computing: Philosophy, Applications, and Opportunities". International Guest Lecture at SRM University, Ramapuram Campus, April 2021. Invited by R. Angeline and K. Raja.
5. "An efficient high-order meshless method for Advection-Diffusion Equations on Time-varying Irregular Domains", Online Seminars on Numerical Approximation and Applications (OSNA^2), November 2020. Invited by Victor Bayona, Costanza Conti, Emma Perracchione, and Rosanna Campagna.
6. "An efficient high-order meshless method for Advection-Diffusion Equations on Time-varying Irregular Domains", Approximation Theory and Numerical Analysis, American Mathematical Society (AMS) Sectional Meeting, October 2020. Invited by Akil Narayan and Vera Babenko.
7. "Automatic Hyperviscosity-based Stabilization of RBF-FD Discretizations", Approximation Theory 16, session on meshless methods, May 2019.
8. "RBF-FD for PDEs on Manifolds: Stable and Stagnation-free Formulations", SIAM Conference on Computational Science and Engineering Minsymposium on Meshfree Methods: Computational Advances and Applications, March 2019. Invited by Grady Wright.
9. "A high-order meshfree framework for solving PDEs on irregular domains and surfaces ", Colorado School of Mines, April 2018. Invited by Greg Fasshauer.
10. "A high-order meshfree framework for solving PDEs on irregular domains and surfaces ", Boise State University, February 2018. Invited by Grady Wright.
11. "A high-order meshfree framework for solving PDEs on irregular domains and surfaces ", University of Massachusetts Dartmouth, January 2018. Invited by Sigal Gottlieb.
12. "KernelPack: A C/C++ library for high-order RBF-FD methods and automatic node generation on irregular domains", Software Session, ICERM Topical Workshop on Localized Kernel-Based Meshless Methods for Partial Differential Equations, Brown University, August 2017. Invited by Natasha Flyer, Oleg Davydov, Bengt Fornberg, and Elisabeth Larsson.
13. "Efficient High-Order RBF-FD methods for Advection-Diffusion-Reaction Equations on Irregular Domains", ICERM Topical Workshop on Localized Kernel-Based Meshless Methods for Partial Differential Equations, Brown University, August 2017. Invited by Natasha Flyer, Oleg Davydov, Bengt Fornberg, and Elisabeth Larsson.
14. "A high-order meshfree framework for solving PDEs on irregular domains and surfaces ", Colorado School of Mines, June 2017. Invited by Greg Fasshauer.
15. "A high-order meshfree framework for solving PDEs on irregular domains and surfaces ", National Center for Atmospheric Research, May 2017. Invited by Natasha Flyer.
16. "A Meshfree Framework for Solving PDEs on arbitrary domains and surfaces", Modeling Complex Fluids and Gels for Biological Applications. Organizer, May 2017.
17. "The Overlapped RBF-FD Method", SIAM CSE 2017, Minisymposium on Meshfree Methods. Invited by Nathaniel Trask.

18. "Radial Basis Function (RBF)-Based Meshfree Methods for Advection-Diffusion-Reaction PDEs on Arbitrary Surfaces", SIAM Conference on Mathematical Aspects of Material Science Minisymposium on Particle Methods, May 2016. Invited by Nathaniel Trask.
19. "Radial Basis Function (RBF)-Based Meshfree Methods for Transport on the Sphere and Other Surfaces", 15^{th} International Conference on Approximation Theory, May 2016. Invited by Edward Fuselier.
20. "Radial Basis Function (RBF)-Based Meshfree Methods for Transport on the Sphere", Boise State University, March 2016. Invited by Grady Wright.
21. "A Radial Basis Function (RBF)-Based Leray Projection Method for the Incompressible Unsteady Stokes Equations", Applied Math Seminar, Arizona State University, September 2015. Invited by Rodrigo Platte.
22. "A Radial Basis Function (RBF)-Based Leray Projection Method for the Incompressible Unsteady Stokes Equations", SIAM CSE 2015, Minisymposium on Meshfree Methods. Organizer.
23. "RBF-FD for the solution of Diffusion and Reaction-Diffusion Equations on surfaces", International Conference on Spectral and High-Order Methods (ICOSAHOM), June 24, 2014. Invited by Rodrigo Platte.
24. PhD Thesis Defense. "Radial Basis Function-Based Numerical Methods for the Simulation of Platelet Aggregation", April 18, 2014.
25. "Radial Basis Functions for the simulation of platelet aggregation", Applied Mathematics Seminar, Department of Mathematics, University of Utah, October 28, 2013.
26. "RBF-FD for the solution of Reaction-Diffusion Equations on surfaces in $\mathbb{R}^3$", Fluids/Gel Seminar, Department of Mathematics, University of Utah, September 11, 2013.
27. "RBF-FD for reaction-diffusion equations on manifolds and RBF symmetric Hermite interpolation-based modifications to forcing methods", SIAM Annual Meeting Minisymposium on "Advances in Radial Basis Function and Other Meshfree Methods", July 9, 2013. Invited by Edward Fuselier.
28. "Using RBFs within the Immersed Boundary method", SIAM Conference on Computational Science and Engineering Minisymposium on "Recent Advances in Immersed Boundary Methods", February 25, 2013. Invited by Boyce Griffith and Robert Guy.
29. (Poster) "Using RBFs within the Immersed Boundary method", 25th Annual Pacific Northwest Numerical Analysis Seminar, October 27, 2012. Invited by Grady Wright, Donna Calhoun and Jodi Mead.
30. "RBF methods for chemical transport in clotting", June 17, 2012, Graphics Seminar, School of Computing, University of Utah.
31. "An RBF Immersed Boundary Method", December 2, 2011, Fluids/Gel Seminar, Department of Mathematics, University of Utah.
32. "A CUDA (GPGPU) Implementation of the 2D Immersed Boundary Method", April 11, 2010, Fluids/Gel Seminar, Department of Mathematics, University of Utah.
33. "The Immersed Boundary Method", March 2, 2010, Graphics Seminar, School of Computing, University of Utah.

Professional Societies

I am currently a member of the Society for Industrial and Applied Mathematics (SIAM) and the American Mathematical Society (AMS). I am also a member of the Sigma Xi Research Honor Society.

Computer Skills

- Languages: C/C++, Fortran, Java, Android, SQL, Python.
- Numerical computation packages: PETSc, SAMRAI, Armadillo, Eigen.
- MATLAB (Octave, SciLab), R
- Parallel Programming: MPI, OpenMP, CUDA.