

Sachin Shivakumar

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Education

- **Ph.D. in Mechanical Engineering** (May 2024), Arizona State University, GPA: 4.0/4.0
 - Dissertation Title: "Analysis, Estimation, and Control of Partial Differential Equations using Partial Integral Equation Representation"
 - Thesis Advisor: Matthew Peet
 - Thesis Committee: Angelia Nedich, Hamidreza Marvi, Rodrigo Platte, Spring Berman
 - **M.S. in Mechanical Engineering** (May 2018), Arizona State University, GPA: 4.0/4.0
 - **B.Tech. (Honors) in Mechanical Engineering** (May 2015), Indian Institute of Technology, Kharagpur, GPA: 7.78/10
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Awards

- 2024: Outstanding Graduate Research Award, Arizona State University.
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Research Focus/Interests

- Development of mathematical/computational tools for analyzing, estimating, and controlling systems governed by Partial Differential Equations (PDEs).
 - Utilization of convex optimization-based techniques to tackle complex engineering problems.
 - Solving fundamental problems in systems and control engineering.
 - Strong interest in numerical methods, computational science, stochastic systems, and nonlinear systems.
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Publications Summary

I have 10 (being the first author for 5) conference papers, all published in the proceedings of IEEE CDC or ACC (listed as the number 1 and 2 top conferences in control theory based on h5-index). I also contributed a chapter as the first author for a book published by Springer on the state-of-the-art control of underwater soft robots. Lastly, I have two journal papers under review one in IEEE TAC and another in IEEE LCSS. All publications are available for public access on control.asu.edu and a few key publications are listed below (**the full list is attached at the end**).

- **Shivakumar, S.**, Das, A., & Peet, M. M. (2020, July). PIETOOLS: A MATLAB toolbox for manipulation and optimization of partial integral operators. In 2020 American Control Conference (ACC) (pp. 2667-2672). IEEE.
 - **Shivakumar, S.**, Das, A., Weiland, S., & Peet, M. M. (2020, December). Duality and H_∞ -optimal control of coupled ODE-PDE systems. In 2020 59th IEEE Conference on Decision and Control (CDC) (pp. 5689-5696). IEEE.
 - **Shivakumar, S.**, Das, A., Weiland, S., & Peet, M. M. (2019, December). A generalized LMI formulation for input-output analysis of linear systems of ODEs coupled with PDEs. In 2019 IEEE 58th Conference on Decision and Control (CDC) (pp. 280-285). IEEE.
 - Jagt, D., **Shivakumar, S.**, Seiler, P., & Peet, M. (2022). Efficient Data Structures for Representation of Polynomial Optimization Problems: Implementation in SOSTOOLS. IEEE Control Systems Letters, 6, 3493-3498.
 - **Shivakumar, S.** et al. (2021). Decentralized Estimation and Control of a Soft Robotic Arm. In: Paley, D.A., Wereley, N.M. (eds) Bioinspired Sensing, Actuation, and Control in Underwater Soft Robotic Systems. Springer, Cham.
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Work and Teaching Experience

Graduate Research Assistant, SEMTE, Feb 2018 - May 2024

- Worked on solving fundamental problems in the Control of distributed parameter systems. Funded by NSF: CMMI-1935453, CNS-1739990.
- Developed decentralized control actions for octopus-inspired soft-robotic arms. Funded by ONR: N00014-17-1-2117.
- Solved the scalability issues, in terms of computation and memory complexity, of Sum-of-Squares programs by developing a new data structure for the representation of polynomial-valued decision variables in convex-optimization problems. Funded by NSF: CMMI-1931270, CMMI-1935453.

MAE Lead Tutor, FSE tutoring center, Jan 2017 - Feb 2018

- Managed schedules and tutored students in the freshman, sophomore, and junior courses of physics, mathematics, and mechanical engineering under ASU's student welfare program

Computer Lab Assistant, School of Mathematical and Statistical Sciences, May 2017 - Jul 2017

- Set up and maintained Linux systems for the courses Applied Linear Algebra and Differential Equations

- Tutored students and conducted review classes in MATLAB for Applied Linear Algebra and Differential Equations

MAE Teaching Aide, *SEMTE*, Jan 2017 - May 2017

- Lead recitation classes for the sophomore course Advanced Mathematical Methods in Engineering
- Performed other duties such as proctoring, student grading, and tutoring for the course

Senior Engineer, *Robert Bosch Engineering and Business Solutions Pvt Ltd.*, Jul 2015 - Jul 2016

- Optimized manufacturing processes as part of the Industry 4.0 Initiative within Bosch.
 - Developed backend data mining/prediction algorithms.
 - Implemented SVM models that predicted a 5% improvement in FPY for fuel injector assembly.
 - Devised control parameters for statistical process control and implemented a prediction-alert system to reduce field failure rates.
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Academic Projects

PIETOOLS - MATLAB Toolbox for PDEs (Fall 2020)

- Developed a MATLAB toolbox for analyzing and controlling linear PDEs using convex optimization techniques.
- Included a symbolic parser, GUI, and simulation modules for end-to-end controller and observer design.

SOSTOOLS - dpvar data structure (2021):

- Developed a *dpvar* data structure to significantly reduce the computational complexity and memory complexity of the polynomial operations in the parsing of Sum-Of-Squares programs.
- Reduced the computational complexity by an order of 10^2 for most algebraic operations.

Qualitative Analysis of Bardina Scale Similarity Models (Fall 2018)

- Performed a qualitative analysis of modeling accuracy in Bardina Scale Similarity Models used during LES simulations.
- Focused on the effects of filter choice and filter scales.

Laminar Flow Mixing Chamber (Spring 2017)

- Implemented fractional step method to improve mixing accuracy by 30% in a mixing chamber setup with miscible liquids.

Building Architectures for Parallel Computing (Fall 2016)

- Developed MPI and co-array compatible programs for parallel processing on a processor cluster with 2D topology.
- Utilized a rotating communication algorithm to optimize performance.

Undergrad Thesis Project, IIT Kharagpur (Jul 2014 - May 2015)

- Solved multicomponent flow for linear and nonlinear sloshing phenomenon through numerical solution techniques.
 - Implemented adaptive mesh corrections to improve robustness in the case of high deformation in the body-fitted mesh.
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Skills and Expertise

- **Programming Languages:** MATLAB, Simulink, Python, C++, Fortran
- **Tools/Frameworks:** OpenMP, MPI, Bash Shell scripting, Linux, Git
- **Research Areas:** Numerical Methods, Distributed Systems, Optimal and Robust Control, Convex Optimization
- **Relevant Coursework:** Modeling and Control of Robots, Geometric Control, Heat and Mass Transfer, Combustion, CFD, Turbulence, FEM, Functional Analysis, Machine Learning, High-Performance Computing

List of Publications

Citation count from Scopus (as of date 4/15/2024): total count 73

Peer Reviewed

Book Chapter (Total Citations 3)

1. **Shivakumar, S.**, Aukes, D. M., Berman, S., He, X., Fisher, R. E., Marvi, H., & Peet, M. (2021). Decentralized estimation and control of a soft robotic arm. *Bioinspired Sensing, Actuation, and Control in Underwater Soft Robotic Systems*, 229-246. (Citations 3)

Journals (Total Citations 1)

1. Jagt, D., **Shivakumar, S.**, Seiler, P., & Peet, M. (2022). Efficient Data Structures for Representation of Polynomial Optimization Problems: Implementation in SOSTOOLS. *IEEE Control Systems Letters*, 6, 3493-3498. (Citations 1)
2. **Shivakumar, S.**, and Matthew Peet. A Computational Method for H_2 -optimal Estimator and State Feedback Controller Synthesis for PDEs. *IEEE Control Systems Letters*. (In review)
3. **Shivakumar, S.**, Das, A., Weiland, S., & Peet, M. (2022). Extension of the partial integral equation representation to GPDE input-output systems. *IEEE Transactions on Automatic Control*. (In review)

Conference proceedings (Total Citations 69)

1. **Shivakumar, S.**, Das, A., & Peet, M. (2023). Representation of linear PDEs with spatial integral terms as Partial Integral Equations. In *2023 American Control Conference (ACC)* (pp. 1788-1793). IEEE. (Citations 0)
2. Peet, M., & **Shivakumar, S.** (2022). Control of Large-Scale Delayed Networks: DDEs, DDFs and PIEs. *IFAC-PapersOnLine*, 55(30), 97-102. (Citations 0)
3. Das, A., **Shivakumar, S.**, Peet, M., & Weiland, S. (2020). Robust analysis of uncertain ODE-PDE systems using PI multipliers, PIEs and LPIs. In *2020 IEEE Conference on Decision and Control (CDC)* (pp. 634-639). IEEE. (Citations 6)
4. **Shivakumar, S.**, Das, A., & Peet, M. (2020). PIETOOLS: A MATLAB toolbox for manipulation and optimization of partial integral operators. In *2020 American Control Conference (ACC)* (pp. 2667-2672). IEEE. (Citations 15)
5. **Shivakumar, S.**, Das, A., Weiland, S., & Peet, M. (2020). Duality and H_∞ -optimal control of coupled ODE-PDE systems. In *2020 IEEE Conference on Decision and Control (CDC)* (pp. 5689-5696). IEEE. (Citations 13)
6. **Shivakumar, S.**, Das, A., Weiland, S., & Peet, M. (2019). A generalized LMI formulation for input-output analysis of linear systems of ODEs coupled with PDEs. In *2019 IEEE Conference on Decision and Control (CDC)* (pp. 280-285). IEEE. (Citations 8)
7. Das, A., **Shivakumar, S.**, Weiland, S., & Peet, M. (2019). H_∞ optimal estimation for linear coupled PDE systems. In *2019 IEEE Conference on Decision and Control (CDC)* (pp. 262-267). IEEE. (Citations 8)
8. Peet, M., **Shivakumar, S.**, Das, A., & Weiland, S. (2019). Discussion paper: A new mathematical framework for representation and analysis of coupled PDEs. *IFAC-PapersOnLine*, 52(2), 132-137. (Citations 6)
9. **Shivakumar, S.**, & Peet, M. (2019). Computing input-output properties of coupled linear PDE systems. In *2019 American Control Conference (ACC)* (pp. 606-613). IEEE. (Citations 4)
10. Doroudchi, A., **Shivakumar, S.**, Fisher, R. E., Marvi, H., Aukes, D., He, X., ... & Peet, M. (2018). Decentralized control of distributed actuation in a segmented soft robot arm. In *2018 IEEE Conference on Decision and Control (CDC)* (pp. 7002-7009). IEEE. (Citations 9)

Unpublished/Not peer-reviewed

1. Baker, L. S., **Shivakumar, S.**, Armbruster, D., Platte, R. B., & Zlotnik, A. (2023). Linear System Analysis and Optimal Control of Natural Gas Dynamics in Pipeline Networks. (To be submitted)
2. **Shivakumar, S.**, Das, A., Weiland, S., & Peet, M. (2023). H_∞ -optimal control of coupled ODE-PDE systems using PIE framework and LPIs. *IEEE Transactions on Automatic Control*. (To be submitted)
3. Wu, S., Peet, M., **Shivakumar, S.**, & Hua, C. (2020). H_∞ -optimal estimation in the PIE framework for systems with multiple delays and sensor noise. (To be submitted)
4. **Shivakumar, S.**, Jagt, D., Braghini, D., Das, A., & Peet, M. (2021). PIETOOLS 2022: User Manual. arXiv e-prints, arXiv:2101.
5. Wu, S., **Shivakumar, S.**, Peet, M., & Hua, C. (2020). H_∞ -Optimal Observer Design for Linear Systems with Delays in States, Outputs and Disturbances. arXiv preprint arXiv:2004.04482.

6. Das, A., **Shivakumar, S.**, Weiland, S., & Peet, M. (2018). Representation and stability analysis of PDE-ODE coupled systems. arXiv preprint arXiv:1812.07186.
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Talks/Presentations

1. Representation of linear PDEs with spatial integral terms as Partial Integral Equations. In 2023 American Control Conference (ACC). IEEE.
2. PIETOOLS: A MATLAB toolbox for manipulation and optimization of partial integral operators. In 2020 American Control Conference (ACC). IEEE.
3. Duality and H_∞ -optimal control of coupled ODE-PDE systems. In 2020 IEEE Conference on Decision and Control (CDC). IEEE.
4. A generalized LMI formulation for input-output analysis of linear systems of ODEs coupled with PDEs. In 2019 IEEE Conference on Decision and Control (CDC). IEEE.
5. Computing input-output properties of coupled linear PDE systems. In 2019 American Control Conference (ACC). IEEE.
6. Decentralized control of distributed actuation in a segmented soft robot arm. In 2018 IEEE Conference on Decision and Control (CDC). IEEE.