SUPARNO BHATTACHARYYA

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RESEARCH INTERESTS

My research predominantly revolves around the reduced order modeling of dynamical systems, with a current emphasis on the hyper-reduced order models of thermal and reservoir systems for developing digital twins. Previously, I have worked on the data-driven modeling of vibro-impact systems and efficient dynamic topology optimization for 2D lattice-structures. Throughout my Ph.D., I focused on reduced-order modeling for structural systems exposed to discontinuous and non-smooth loading conditions. During my master's degree, I worked on the experimental assessment of structural damping in metals. My comprehensive research interests encompass reduced order modeling, finite element analysis, computational mechanics, and nonlinear dynamics. Additionally, I am a proficient polyglot programmer with expertise in MATLAB, Mathematica, and Python. This diverse background equips me with a comprehensive understanding and a unique perspective on the challenges and solutions in the field of computational mechanics and reduced order modeling.

PROFESSIONAL EXPERIENCE

Postdoctoral scholar, Digital Twin Lab, Institute of Data Science (TAMIDS) *2023-Present*
Texas A&M University, Texas, USA
Research topic: Reduced order modeling, Digital Twin.

Postdoctoral scholar, The Department of Automotive Engineering *2022-2023*
Clemson University, South Carolina, USA
Research topic: Data-driven model discovery of dynamical systems, Dynamic modeling of lattice structures for efficient topology optimization.

EDUCATION

PhD, Engineering Science and Mechanics *2021*
Minor: Computational Science
The Pennsylvania State University, PA, USA
Advisor: Prof. Joseph Cusumano
Thesis: Model Reduction of Dynamical Systems Subjected to Impacts and Discontinuity
GPA: 3.90/4.00

M.Tech, Mechanical Engineering (Solid Mechanics) *2014*
Indian Institute of Technology Kanpur, India
Advisor: Prof. Anindya Chatterjee
Thesis: Experimental study of damping enhancement in aluminium rods by knurling
GPA: 9.00/10.00

BE, Mechanical Engineering *2012*
Jadavpur University, Kolkata, India
GPA: 8.35/10.00

PRESENTATIONS AND PUBLICATIONS

Journal Publications

J5. **Bhattacharyya, S.**, and Cusumano, J., "Model Reduction of a Piecewise Nonlinear Mechanical Oscillator", in Proceedings of the Royal Society A (Submitted, in review, preprint: arxiv.org/abs/2311.17947).

..... ↑ Journal papers above this line are currently under the first round of review and have not received any reviewer feedback ↑ .....

J4. **Bhattacharyya, S.**, **Khawale, R.***, Rai, R., Dargush, G., "Efficient dynamic topology optimization of 2D metamaterials based on complementary-energy formulation." Computers & Structures (acceptance rate 8%), vol. 299, pp. 107371, 2024.

J3. **Bhattacharyya, S.**, and Cusumano, J. P., "Experimental Implementation of Energy Closure Analysis for Reduced Order Modeling." ASME, Journal of Vibration and Acoustics, 144(5): 051007, 2022.

J2. **Bhattacharyya S.**, and Cusumano J., "An Energy Closure Criterion for Model Reduction of a Kicked Euler-Bernoulli Beam", ASME, *Journal of Vibration and Acoustics*, 143(4): 041001, 2021. ***The paper has been nominated for an ASME Journal of Vibration and Acoustics spotlight presentation at the 2021 ASME IDETC***.

J1. **Bhattacharyya S.** and Naskar T.K. (2011), "Analysis of the Effect of Number of Knots in a Trajectory on Motion Characteristics of a 3R Planar Manipulator" *International Journal of Mechanical and Industrial Engineering*, 1(2), pp. 51-56, 2011.

Manuscript Under Preparation

M2. **Bhattacharyya, S.**, Huhn, Q., Tao, J., Gildin, E., Ragusa, J., "Hyper-reduction Methods for Large-Scale Engineering Systems: A Tutorial Review."

M1. **Bhattacharyya, S.**, **Alsalih, H.**, Choi, Y., Lee, K., Rai, R. "Data-Driven Model Discovery of Flexible Structures."

Book Chapters

B3. Kumar A., and **Bhattacharyya S.**, "Methods and Materials for Advanced Manufacturing (MMAM) of MEMS/NEMS-Enabled Bio-Electronics and Wearables for Health Monitoring", Basu A.K., Basu A., Ghosh S., Bhattacharya S. (Eds.), MEMS Applications in Biology and Healthcare, AIP Publishing, Melville, New York, 2021.

B2. **Bhattacharyya S.**, and Kumar, A., "Mechanics of Materials Considerations in MEMS-Based Medical Devices," , Basu A.K., Basu A., Ghosh S., Bhattacharya S. (Eds.), MEMS Applications in Electronics and Engineering, AIP Publishing, Melville, New York, 2023.

B1. Basu A. K., and **Bhattacharyya S.**, "Scaling Law", Basu A.K., Basu A., Ghosh S., Bhattacharya S. (Eds.), MEMS Applications in Electronics and Engineering, AIP Publishing, Melville, New York, 2023.

Refereed Proceedings

RP7. **Bhattacharyya, S.**, Tao, J., Gildin, E., Ragusa, J., "Uncertainty Quantification With Hyper-Reduced Order Model," *to be presented at* ASME Verification, Validation, and Uncertainty Quantification Symposium 2024: May 15-17, 2024, College Station, Texas.

*co-first authors.

RP6. **Bhattacharyya, S.**, Tao, J., Gildin, E., Ragusa, J., "Model Reduction of a Piecewise Nonlinear Mechanical Oscillator," 6th Annual Meeting of the SIAM Texas-Louisiana Section (TXLA23): Nov 3-5, 2023, Lafayette, Louisiana.

RP5. **Bhattacharyya, S.**, Cusumano, J. "Model Reduction of a Piecewise Nonlinear Mechanical Oscillator," 17th U. S. National Congress on Computational Mechanics: July 23-27, 2023, Albuquerque, New Mexico.

RP4. **Bhattacharyya, S.**, **Alsalih, H.***, Choi, Y., Lee, K., Rai, R. "Data-Driven Model Discovery of Flexible Structures," 17th U. S. National Congress on Computational Mechanics: July 23-27, 2023, Albuquerque, New Mexico.

RP3. Khawale, R.,**Bhattacharyya, S.**, Bielecki, B., Rai, R., Dargush, G., "Efficient methods for flexibility based meso-scale dynamic modeling," presented at IMAC-XLI: a Conference on Structural Dynamics : February 13-16, 2023, Renaissance Austin Hotel, Austin, Texas, organized by: Society for Experimental Mechanics, Inc.

RP2. **Bhattacharyya, S.**, and Cusumano, J., "The Importance of Energy Criteria for Selecting Modes in Reduced Order Modeling," Proceedings of the ASME 2019 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference. Volume 8: 31st Conference on Mechanical Vibration and Noise. Anaheim, California, USA. August 18–21, 2019.

RP1. **Bhattacharyya, S.**, and Naskar, T.K., "The effect of number of knots in a polynomial trajectory on motion characteristics of robotic manipulators," Proceedings of the 9th International Conference on Mechanical Engineering. Organized by Bangladesh University of Engineering and Technology (BUET), Dhaka, Bangladesh. December 18–20, 2011.

Presentations

P2. **Bhattacharyya S.**, Cusumano J., "Energy criterion for enhanced accuracy of Reduced Order Models," ESM Today 2018, Penn State University, USA.

P1. Kumar A., Chatterjee K., **Bhattacharyya S.**, "A review on corrosion control methods with electroless coatings," National symposium of micro and nano characterization of materials 2011, Jadavpur University, India. *(Obtained 2nd prize)*

RESEARCH EXPERIENCE

Institute of data Science, Texas A&M University, USA *2023-present*
Postdoctoral scholar

Hyper-reduction for enhancing the efficacy of Digital Twins (with Prof. Jean Ragusa, Prof. Eduardo Gildin, and Prof. Jian Tao):

- Implementation and development of hyper-reduction algorithms to develop digital twins focused on neutron transport phenomenon in nuclear reactors, and reservoir simulations.
- Developing a GitHub repository, which features linear and nonlinear finite element models in thermal, structural, and fluid systems, including detailed illustrations of hyper-reduction algorithm applications to improve computational performance.

Department of Automotive Engineering, Clemson University, USA *2022-2023*
Postdoctoral scholar

Project #1 Efficient dynamic topology optimization of 2D metamaterials based on a complementary ernergy formulation (in collaboration with Prof. Gary Dargush at Univ of Buffalo):

- Pioneered a dynamic Topology Optimization framework for printable lattice structures, targeting the attainment of specified dynamic properties.
- Implemented parametric filament-based unit cell structures within the framework to control natural frequency bandgaps effectively.
- Utilized a novel complementary energy-based approach for computing flexibility and stiffness, enhancing computational efficiency by reducing reliance on extensive finite element analysis.
- Demonstrated the framework's efficacy by successfully maximizing band-gap properties in 2D lattice structures through geometric optimization in each cell.

Project #2

Data-driven model discovery of dynamical systems (in collaboration with Prof. Kookjin Lee at Univ of Arizona and Dr. Youngsoo Choi at Lawrence Livermore National Lab):

- Implemented the data-driven modeling techniques: Dynamic mode decomposition and LaSDI (Latent Space Dynamics Identification) for discovering models from structural vibration data.
- Investigated how effectively *neural ODEs* may be integrated with LaSDI for model discovery from vibration data.

Department of Engineering Science and Mechanics, Penn State University *2014 - 2021*
Graduate Research Assistant

Pursued Ph.D. on model order reduction of dynamical systems subjected to impact and discontinuity using data-driven dimension reduction technique Proper Orthogonal Decomposition:

- Performed High-Fidelity structural vibration simulations using FEA and modal analysis in MATLAB.
- Employed Proper Orthogonal Decomposition (POD) on spatio-temporal simulation data to generate computationally efficient reduced order models (ROMs).
- Developed a novel physics-informed criterion for selecting dimension of the ROMs, which yields highly accurate models.
- Explored the application of this criterion for formulating ROMs with experimental data, typically corrupted with measurement noise.
- Demonstrated the effectiveness of physics-informed dimension estimation in generating reliable ROMs for both linear and nonlinear dynamical systems.

Department of Mechanical Engineering, IIT Kanpur *2012 - 2014*
Graduate Research Assistant

Performed experimental study of damping enhancement in aluminum rods by knurling:

- Established that surface deformation processes like knurling can increase structural damping in structural components made of aluminum.
- Engineered an experimental setup to facilitate this study.
- Collected vibration data from the setup utilizing LabVIEW, employing strain gauges and National Instruments DAQ devices for data acquisition.
- Designed both analog and digital filter circuits to mitigate noise in the experimental data.

- Applied optimization techniques to accurately estimate damping parameters from the gathered data.
- Corroborated the findings of increased damping through both theoretical analysis and simulations conducted in ANSYS Fluent.

Department of Mechanical Engineering, Jadavpur University *2008 - 2012*
Undergraduate Research Assistant

Project #1

Studied trajectory planning of planar robotic manipulators

- Showed that increasing the number of control points (knots) while designing trajectory of a 3R manipulator, even though increases its accuracy, can lead to significant fluctuations in velocity, acceleration, and jerk of the manipulator.
- Performed simulation of the motion of a robotic manipulator using AutoLISP language on the AutoCAD platform.

Project #2

Analyzed deformation and deflection of beams with channel cross-section under different loading conditions in ANSYS.

TEACHING EXPERIENCE

Institute of data science, Texas A&M University *2024*
Instructor
TAMIDS workshop: Dive into Reduced Order Modeling with pylibROM

Collaborative workshop on Reduced Order Modeling (ROM), organized in partnership with Texas A&M High Performance Research Computing and the libROM team at Lawrence Livermore National Laboratory (LLNL).

Department of Petroleum Engineering, Texas A&M University *2023*
Guest lecturer
PETE 689: Physics-based and Data-Driven Reduced-Order Modeling for Engineering Systems

Offered workshop style lectures on pyMOR, a python library for model order reduction applications, as a part of the course.

Department of Engineering Science and Mechanics, Penn State *2014 - 2021*
Teaching assistant
EMCH 210: Statics and strength of materials, EMCH 212: Dynamics, EMCH 316: Experimental Determination of Mechanical Response of Materials

- Conducted a total of 28 lectures for the course EMCH 212 across two separate sections in the Fall semesters of 2015 and 2016.
- Oversaw and evaluated tests, quizzes, and weekly homework assignments for an average class size of 300 students, coordinating with a team of six teaching assistants.
- Maintained regular office hours and organized weekly tutoring sessions, assisting students in understanding course material, completing assignments, and enhancing academic performance.
- As the lead teaching assistant (TA) for multiple semesters, I mentored new TAs and supervised the grading process during examinations.
- Acquired proficiency in Learning Management Systems such as CANVAS and ANGEL .

Department of Mechanical Engineering, IIT Kanpur *2013 - 2014*
Teaching assistant (TA202: Manufacturing Lab)

- Executed the comprehensive duties of a Teaching Assistant, effectively managing a class of 400 students, ensuring smooth educational operations.
- Diligently assessed and graded project reports, maintaining an up-to-date and accurate record of student grades.
- Provided detailed and insightful feedback to students, guiding them towards academic improvement and deeper understanding.
- Oversaw laboratory sessions, ensuring a conducive learning environment and offering necessary supervision to students.

Self Employed, Pennsylvania, USA *2017 - 2019*
Volunteer – Math and Physics Tutor (private)

Volunteered to tutor two students, one from middle school and another from high school, in the local community, offering personalized educational support.

- Conducted one-on-one tutoring sessions in Advanced Geometry, Advanced Algebra, Pre-calculus, and AP Physics, tailoring instruction to each student's learning style.
- Assisted the students with homework, projects, and preparation for school exams and weekly quizzes, enhancing their academic performance.
- Created customized learning materials to address the unique educational needs and objectives of each student.

CERTIFICATIONS

Summer school: Solving large systems efficiently in multiphysics numerical simulations *2021*
Centre de recherches mathématiques (CRM), Univesity of Laval

A program to introduce the participants to fundamental techniques for solving large multiphysics problems: (i) stationary iterative methods, (ii) domain decomposition, and (iii) multigrid methods, and to well-designed problem sets to experiment with, and to explore the mathematics behind these techniques.

Machine Learning *2020*
Offered by Stanford University via Coursera (online learning platform)

- Supervised learning (parametric/non-parametric algorithms, support vector machines, kernels, neural networks).
- Unsupervised learning (clustering, dimensionality reduction, recommender systems, deep learning).

Graduate Student Online Teaching Certificate *2019*
The Pennsylvania State University, World Campus

A training program to structure and teach an online course through various activities that ensure effective discourse with students. Activities include discussion management, assessment techniques, developing learning activities, reflective practice, and planning for future development and community building.

RELATED PROFESSIONAL SKILLS

Data Science:	Machine Learning, Tensor Flow, Pytorch
Programming Languages:	MATLAB, Python, C++
Software & Tools:	ANSYS (Completed a certified online course offered by Cornell University), Mathematica, Maple, NI LabVIEW, AutoCAD, LaTeX, MS Office
High Performance Computing:	MPI, OpenMP, CUDA, Parallel computation in MATLAB

HONORS & ACHIEVEMENTS

- Received the Graduate Student Travel Award from the Engineering Science and Mechanics Department at Penn State University for the MMLDT-CSET 2021 conference.
- Achieved an All India Rank of 96 among 112,320 candidates in the 2012 Graduate Aptitude Test in Mechanical Engineering, a pivotal entrance exam for M.Tech programs at the Indian Institutes of Technology and Indian Institute of Science.
- Attained a rank of 378 in the Engineering category of the State Joint Entrance Examination (WBJEE) in 2008, standing out among approximately 70,000 students.

RELEVANT COURSEWORK

Applied statistics, Numerical solution of partial differential equations, Vibration of continuous systems, Nonlinear dynamics, Numerical solution of ordinary differential equations, Finite element method, Concurrent scientific programming (high performance computing), Mathematical methods in engineering, A Hands-on introduction to engineering simulations (Online course offered by Cornell University), Continuum mechanics, Theory of elasticity, Theory of plasticity, Rotor dynamics, Introduction to modern control theory (self-taught).

ACADEMIC OUTREACH ACTIVITIES

Organizer
ESM Today, Pennsylvania State University

Served as the organizing member of ESM Today 2020, Engineering Science and Mechanics department's annual research symposium.

Reviewer
College of Engineering Research Symposium, Pennsylvania State University

Served as the reviewer for CERS, the annual research symposium organized by Engineering Graduate Student Council, Penn State.

ASME Manufacturing Science and Engineering Conference

Served as a reviewer for MSEC, 2022 organized by American Society of Mechanical Engineers.

OUTREACH OF SERVICE

Vice president
Society for Indian Music and Arts, Pennsylvania State University

A student-led organization dedicated to the rich and expressive traditions of the performing arts of South Asia.

Committee member
Happy Valley Indian Performing Arts Festival, Pennsylvania State University

Organized by Society for Indian Music and arts.

Judge
Engineering's Got Talent, Pennsylvania State University

Sponsored by the Engineering Graduate Student Council and Engineering Undergraduate Council.

Organizer

Helped organize multiple community events for the local Indian community.

PROFESSIONAL AFFILIATIONS

- Member of American Society for Mechanical Engineers (ASME)
- Member of Society for Industrial and Applied Mathematics (SIAM)
- Member of American Institute of Aeronautics and Astronautics (AIAA)

REFERENCES

Prof. Joseph Cusumano
Pennsylvania State Univerisity, (+1) 814-865-3179, jpc3@psu.edu

Department of Engineering Science and Mechanics, 212 Earth-Engineering Sciences Bldg, Penn State University, University Park, PA 16802.

Prof. Gary Dargush
University at Buffalo, (+1) 716-645-2315, gdargush@buffalo.edu

Department of Mechanical and Aerospace Engineering, 223 Bell Hall, University at Buffalo, Buffalo, NY, 14260.

Prof. Kookjin Lee
Arizona State University, kookjin.lee@asu.edu

School of Computing and Augmented Intelligence, Arizona State University, 699 S Mill Ave BYENG 568 Tempe, AZ, 85281.

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