Saurabh Deshpande

PhD in Scientific Machine Learning

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Education

University of Luxembourg: Doctoral Program in Computational Sciences
MSCA PhD candidate. Supervisor: Prof. Stéphane Bordas — *Aug 19 - present*

Indian Institute of Technology Madras, India — **CGPA: 8.5/10.0**
Dual Degree: B.Tech & M.Tech, Mechanical Engineering — *Jul 12 - May 17*

Research visits

Team Mimesis - INRIA, Strasbourg
Deep learning for biomechanical simulations. Host: Prof. Stéphane Cotin — *March 22 - April 22*

Technical University of Munich
Semester abroad/research assistant, Mechanical Engineering — *April 16 - July 16*

Publications

Google scholar
Researchgate
orcid

S. Deshpande, J. Lengiewicz, S.P.A. Bordas (2022). "*Probabilistic Deep Learning for Real-Time Large Deformation Simulations*". Computer Methods in Applied Mechanics and Engineering (CMAME) 398, 11530. https://doi.org/10.1016/j.cma.2022.115307

S. Deshpande, J. Lengiewicz, S.P.A. Bordas. "*MAgNET: A Graph U-Net Architecture for Mesh-Based Simulations*" (2022). arXiv. https://doi.org/10.48550/arxiv.2211.00713

S. Deshpande, R. I. Sosa, J. Lengiewicz, S.P.A. Bordas. "*Convolution, aggregation & attention based deep neural networks to accelerate simulations in mechanics*" (2022). arXiv. https://doi.org/10.48550/arxiv.2212.01386

Conference Presentations & Posters

S. Deshpande, J. Lengiewicz, S.P.A. Bordas. "*Real Time Hyper-elastic Simulations with Probabilistic Deep Learning*". World Congress on Computational Mechanics (WCCM-XV), Japan (2022).

S. Deshpande, J. Lengiewicz, S.P.A. Bordas. "*Real-Time Large Deformation Simulations Using Probabilistic Deep Learning Framework*". The Platform for Advanced Scientific Computing (PASC) Conference, Basel (2022).

A. Mazier, T. Lavigne, J. Lengiewicz, **S. Deshpande**, S. Urcun, S. Bordas. "*Towards real-time patient-specific breast simulations: from full-field information to surrogate model* ". World Congress of Biomechanics, Taipei (2022).

S. Deshpande, J. Lengiewicz, S.P.A. Bordas. "*Real-time large deformations: A probabilistic deep learning approach*". The 8th European Congress on Computational Methods in Applied Sciences and Engineering, Norway (2022).

S. Deshpande, S. Bordas, L. Beex, S. Cotin, A. Sarkica. "*Data Driven Surgical Simulations*". World Congress on Computational Mechanics (WCCM-XIV), Paris (2020).

Review activities

Applied Mathematical Modeling (Journal)

Other talks

Informal PhD presentation (click on the year to see the talk) *2022*
Team MIMESIS Seminar, INRIA *2022*
Machine Learning Seminar, Team Legato, University of Luxembourg *2020, 2021, 2021*
First Finite Element Developers Meet: Vikram Sarabhai Space Centre *2017*

Professional Experience

Scientist/Engineer 'SC' in Indian Space Research Organisation (ISRO)
At Space Applications Centre, Department of Space, India *Jul 17 - May 19*

- Member of the team developing mechanisms in satellite payloads & ground segments.

Development of ground segment mechanism for GSAT-29 satellite

- Developed **country's first indigenous** high accuracy optical telescope pointing mechanism.
- It involved DFX & simulation-based design, validation, fabrication, and final integration.
- My design concept was utilized in the onboard payload, which is currently in space.

Development of 6 meter deployable antenna

- Large communication antennas can't be directly launched into space.
- Created a prototype for a foldable antenna whose surface is made from composite fiber mesh.
- Antenna has a fold-able metal outer ring and a cable mesh network made of composite threads
- Mathematically modeled the optimal mesh network for arbitrary paraboloid surface.

Gimbal mechanism for Active Radar Calibrator (ARC)

- Automated the existing manual mechanism of ARC, currently being used in Antarctica.
- The new mechanism avoided human intervention errors thus improving the measurement accuracy by several folds.

Automation of antenna testing procedure of Chandrayaan-2

- Developed a motor-controlled automated mechanism that reduced human intervention and decreased testing time by 95%.

Awards

- **MSCA fellowship** for pursuing doctorate degree in computational sciences. *2019-22*
- Best presentation award at the Machine Learning School, University of Bern (400 CHF). *2022*
- State Bank of India scholarship covering **95% of the tuition fee** at IIT Madras. *2012-17*
- **Travel award** from IWR Heidelberg to attend Bangkok Summer School on Applied Mathematics & Computational Science. *2017*
- **Travel grant** from IIT Madras to present at the First National Finite Element developers conference (One of the less than 10 undergraduates across the country). *2016*
- **Travel grant** from IIT Madras to spend a semester at Technical University of Munich, Germany (accepted) and Seoul National University, South Korea. *2016*
- Recipient of the **KVPY fellowship** from the the Government of India (**top 0.5%**), offering full financial support to pursue a bachelor degree in pure sciences. *2012*
- Recipient of the **INSPIRE fellowship** from the Government of India (**top 0.1%**), offering full financial support to pursue a bachelor degree in pure sciences. *2012*
- Secured a region rank 6 & 26 in competitive **Regional Maths Olympiad**. *2009 & 11*
- In the top 300 in India in National Standard Examination in Astronomy Olympiad. *2010*
- State rank 21 in Maharashtra Talent Search Examination. *2008*

Skills

Languages: Python (proficient), C, C++ (intermediate)
Machine Learning Libraries: TensorFlow, TensorFlow Probability, Keras, PyTorch
Computational Tools: Matlab, Mathematica
Design: (Adobe-) Photoshop, Lightroom, Premier Pro, After Effects
Solid Modelling Tools: Autodesk Inventor, AutoCAD, CREO
Other: git, Markdown, [z|ba]sh, LaTeX

PhD Thesis

Scalable Deep learning techniques for scientific simulations
Supervisor: Prof. Stéphane Bordas, University of Luxembourg *Aug 19 - Ongoing*

- PhD candidate in 'Rapid Biomechanics Simulation for Personalized Clinical Design' (ITN RAINBOW), a Marie Sklodowska-Curie European Training Network.
- Working on a broad range of deep learning techniques for efficient learning on mesh-based data.

Baysian CNNs for real-time large deformation simulations *article*

- Developed a **Bayesian U-Net surrogate framework**, which can accurately predict **non-linear deformations** of soft bodies along with the associated aleatoric and epistemic uncertainties.

MAgNET: A geometric deep learning framework for mesh-based simulations *preprint*

- A novel framework for efficient supervised learning on high dimensional graph-structured data.
- Proposed new deep learning layers: Multichannel Aggregation (MAg) and graph pooling/unpooling.
- MAg extends the concept of convolutional layers to arbitrary non-grid inputs such as graphs.
- Pooling layers enable efficient learning through reduced representations of arbitrary graphs.

Attention based deep neural networks for simulating mechanics of solids *preprint*

- Implemented state-of-the-art attention mechanism-based network, Perceiver IO, to simulate non-linear finite element responses in real-time.
- Validated the performance against CNN and MAgNET approaches by implementing them to real-world geometries.

Predicting nonlinear soft body deformations from partial observations *in preperation*

- MAgNET framework takes sparse partial surface displacement inputs and predicts accurate full-field organ displacements.

Masters Research

Parallel Processing XFEM Solver for Weak Discontinuous Problems
M.Tech Thesis, Supervisor: Prof. Sundararajan Natarajan, IIT Madras *Aug 16 - May 17*

- Developed a domain decomposition framework for solving large scale finite element problems involving inhomogneous materials in **less than 5%** time of the conventional approach.
- Implemented eXtended Finite element (XFEM) along with Finite Element Tearing and interconnecting algorithm.

Finite Element Tearing and Interconnecting (FETI) *May 16 - Jul 16*
Research Assistant, Chair of Applied Mechanics, Technical University of Munich

- Implemented massively **parallel, domain decomposition** numerical algorithm FETI to solve large scale static and dynamics problems arising in structural mechanics.
- Predominantly worked on preprocessing issues of FETI, explored different finite element open source tools for creating partitions with conforming/non-conforming meshes.

Student Supervision

Hardik Jeldiya, "Design and synthesis of support net configuration for deployment space antenna reflector" - Masters thesis at the ISRO.

Thomas Lavigne, "Surrogate Modeling of breast soft tissue deformation" - Masters thesis at the University of Luxembourg.

Jiajia Wang, "An investigation of real-time interactive simulations for intuitive conceptual design" - First year PhD at the University of Luxembourg.

Positions of Responsibilities

Student Representative *June 21 - Present*
- For the Doctoral School in Science and Engineering, University of Luxembourg (∼600 PhDs)
- For the Department of Computational Sciences, University of Luxembourg (∼60 PhDs)
- For Marie Curie ITN Rainbow network (∼15 PhDs)

Mentor, Avanti Fellows: *Aug 14 - May 15*
Part of the team aiming to help students from less privileged backgrounds to clear competitive university entrance exams, personally mentored two students (one admitted to IIT Delhi).

Envisage Coordinator, IIT Madras: *May 13 - Jan 14*
Member of India's largest student organised techno-entertainment show with a 4000 footfall.

Relevant Coursework

Oxford Machine Learning Summer School 2022, Deep Learning Specialisation: Coursera, Inverse problems: a probabilistic approach, Uncertainty Quantification, Proposal writing workshop: ITN Rainbow, Advanced Discretisation methods, Intellectual Property Rights

Extra curricular activities

Outreach *2019*

Tech Fair: European Investment Bank Conference:
Demonstrated haptic technology for its uses in personalised medical simulations.

National Space Society Exhibition: Nashik Chapter: *2018*
Organised an exhibition to educate school children on space engineering and Indian space programs. Attended by 500+ students.

Sports:
- Represented the University of Luxembourg in the PCU Chess cup tournament held at Antwerp.
- Winner of Space application center table tennis tournament, represented my center in inter ISRO competition.
- Represented IIT Madras in **inter-college table tennis** tournament.
- Captain of hostel squash and table tennis team at IIT Madras.
- **2 gold** and **2 silver** medals in squash and **1 gold** and **1 silver** in Waterpolo in the IIT Madras sports tournament (known as Schroeter).
- Represented my district in **Maharashtra state level** Table Tennis tournament.

Music:
- Written/composed two songs, around 5k+ listens on social platforms: Spotify for artist